SEDAR 09

SOUTHEAST DATA, ASSESSMENT, AND REVIEW

Greater Amberjack, *Seriola dumerili*, in the Gulf of Mexico

Stock Assessment Report

Prepared by

SEDAR 09 Stock Assessment Panel

10 March 2006

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1. Introduction

1.1. Workshop Time and Place

The SEDAR 9 Assessment Workshop was held in Miami, FL, August 22 – 26, 2005. A follow-up Assessment Workshop was held in Atlanta, GA, December 19-20, 2005.

1.2. Terms of Reference

1. Select several appropriate modeling approaches, based on available data sources, parameters and values required to manage the stock, and recommendations of the Data Workshop.
2. Provide justification for the chosen data sources and for any deviations from Data Workshop recommendations.
3. Estimate stock parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates and measures of model 'goodness of fit'.
4. Characterize uncertainty in the assessment, considering components such as input data, modeling approach, and model configuration.
5. Provide yield-per-recruit and stock-recruitment analyses.
6. Provide complete SFA criteria. This may include evaluating existing SFA benchmarks or estimating alternative SFA benchmarks (SFA benchmarks include MSY, Fmsy, Bmsy, MSST, and MFMT). Develop stock control rules.
7. Provide declarations of stock status relative to SFA benchmarks: MSY, Fmsy, Bmsy, MSST, MFMT.
8. Estimate Allowable Biological Catch (ABC) and provide an appropriate confidence interval.
9. Project future stock conditions and develop rebuilding schedules if warranted; include estimated generation time. Projections shall be developed in accordance with the following:
    A) If stock is overfished:
        F=0, F=current, F=Fmsy, Ftarget (OY),
        F=Frebuild (max that rebuild in allowed time)
    B) If stock is overfishing
        F=Fcurrent, F=Fmsy, F= Ftarget (OY)
    C) If stock is neither overfished nor overfishing
        F=Fcurrent, F=Fmsy, F=Ftarget (OY)
10. Evaluate the results of past management actions and probable impacts of current management actions with emphasis on determining progress toward stated management goals.
11. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity. Prioritize recommendations based on their likelihood for improving stock assessment.

12. Fully document all activities: Draft Section III of the SEDAR Stock Assessment Report and provide complete tables of estimated values.
    Reports to be finalized and distributed to the panel for review by September 30.
    Comments due to editors by October 14.
    Final version due to Coordinator by October 28.

1.3. List of Participants

1.3.1. Assessment Workshop I, August 22-26 2005

Workshop Participants:
Harry Blanchet..................................LA DWF
Liz Brooks...NMFS/SEFSC Miami, FL
Craig Brown......................................NMFS/SEFSC Miami, FL
Shannon Calay ....NMFS/SEFSC Miami, FL
Guillermo Diaz..................................NMFS/SEFSC Miami, FL
Bob Dixon...NMFS/SEFSC Beaufort, NC
Bob Gill...GMFMC Advisory Panel
George Guillen..................................Univ. Houston Clear Lake/GMFMC SSC
David Hanisko ....NMFS/SEFSC, Pascagoula MS
Walter Ingram ....NMFS/SEFSC Pascagoula MS
Bob Muller ....FL FWCC/GMFMC SSC
Debra Murie ....University of Florida/GMFMC FINFISH SAP
Josh Sladek Nowlis ....NMFS/SEFSC Miami, FL
Scott Nichols ....NMFS/SEFSC Pascagoula MS
Dennis O'Hern ....GMFMC Advisory Panel
Larry Perruso ....NMFS/SEFSC Pascagoula MS
Steven Saul..RSMAS/ SEFSC Miami FL
Jerry Scott ....NMFS/SEFSC Miami, FL
Steve Turner......................................NMFS/SEFSC Miami, FL

Observers:
Kay Williams ....GMFMC
Elizabeth Fetherston...........................Ocean Conservancy
Albert Jones ....GMFMC SSC

Staff:
John Carmichael................................SEDAR
Stu Kennedy......................................GMFMC
Dawn Aring.......................................GMFMC
Patrick Gilles.....................................NMFS/SEFSC Miami FL

1.3.2. Assessment Workshop II, December 19-20 2005

Workshop Participants:

Liz Brooks...NMFS/SEFSC Miami, FL
Craig Brown......................................NMFS/SEFSC Miami, FL
Shannon Calay ....NMFS/SEFSC Miami, FL
Guillermo Diaz..................................NMFS/SEFSC Miami, FL
George Guillen..................................Univ. Houston Clear Lake/GMFMC SSC
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Bob Muller ....FL FWCC/GMFMC SSC
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Observers:

Roy Williams ....GMFMC

Staff:

John Carmichael................................SEDAR
Stu Kennedy......................................GMFMC
Dawn Aring.......................................GMFMC
Patrick Gilles....................................NMFS/SEFSC Miami FL

1.4. List of Assessment Workshop Working Papers, Assessment Workshops I & II

SEDAR9-AW1	Incorporating Age Information into SEAMAP Trawl Indices for SEDAR9 Species	Nicholls, S.
SEDAR9-AW2	Separating Vermilion Snapper Trawl Indexes into East and West Components	Nicholls, S
SEDAR9-AW3	Modeling Shrimp Fleet Bycatch for the SEDAR9 Assessments	Nicholls, S
SEDAR9-AW4	Status of the Vermilion Snapper (*Rhomboplites aurorubens)* Fisheries of the Gulf of Mexico	Cass-Calay, S.
SEDAR9-AW5-REV	Gulf of Mexico Greater Amberjack Stock Assessment	Diaz, Guillermo A., and Elizabeth Brooks
SEDAR9-AW6	A Categorical Approach to Modeling Catch at Age for Various Sectors of the Gray Triggerfish (*Balistes capriscus)* Fishery in the Gulf of Mexico	Saul, Steven and G. Walter Ingram, Jr.

SEDAR9-AW7	Updated Fishery-Dependent Indices of Abundance for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)*	Nowlis, Joshua Sladek
SEDAR9-AW8	An Aggregated Production Model for the Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* Stock	Nowlis, Joshua Sladek and Steven Saul
SEDAR9-AW9	Age-Based Analyses of the Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) Stock	Nowlis, J. S.
SEDAR9-AW10	Gulf of Mexico Greater Amberjack Virtual Population Analysis Assessment	Brown, C. A.,C. E. Porch, and G. P. Scott
SEDAR9-AW11	Rebuilding Projections for the Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) Stock.	Nowlis, J. S.

2. Data Issues and Deviations from Data Workshop Recommendations

2.1. Indices of Abundance

Documents SEDAR9-DW10 and SEDAR9-DW20 presented greater amberjack standardized indexes of abundance for the commercial and recreational fisheries, respectively. The SEDAR9-DW recommended the use of four indices of abundance for the greater amberjack stock assessment: 1) commercial handline (1-9 hooks per line), 2) commercial longline, 3) recreational headboat and 4) recreational charter boat and private boat combined. Trip selection for the CPUE analysis followed the species composition method developed by Stephen and McCall (2000) and already presented during the SEDAR9-DW. However, the 'default' threshold value estimated by this method was reduced between 25% and 50% to increase the number of trips included in the final data sets to be analyzed. Initial exploratory analysis showed that CPUE trends did not change when the threshold value was reduced. Trips selection for the commercial handline (1-9 hooks per line) and the combined private boat and charter boat fisheries were performed by reducing the threshold value by 50%, in the case of the commercial longline fishery the threshold was reduced by 25%. For the headboat fishery, all available trips were used for the analysis of indexes of abundance.

2.2. Revised Catch Series

During Assessment Workshop II, a revised catch series was used for additional model runs, based on the inclusion of landings reported in the category of 'Other jacks', which did not exist in earlier years. This revised series included higher commercial catches for the period 1990-2004, for both commercial hook and line and longline gears. Commercial yield for the period 1963-1989 was unchanged from the original catch series. Yield from recreational gears was not revised from the original catch series.

3.0. Stock Assessment Models and Results

Three stock assessment models were presented at the Stock Assessment workshop, including a Virtual Population Analysis (VPA), a non-equilibrium surplus production model (ASPIC), and a State-Space Age-Structured Production Model (SSASPM). The VPA was presented for continuity with the most recent stock assessment for greater amberjack (Turner et al. 2000). ASPIC and SSASPM were presented because they rely less on knowing the age structure of the catch explicitly, which has been raised as a concern in using the VPA alone for the stock assessment of greater amberjack in the Gulf of Mexico.

3.1. Model 1: Virtual Population Analysis

3.1.1. Model 1: Virtual Population Analysis Methods

3.1.1.1 Overview

The previous assessment (Turner et al. 2000) used a calibrated VPA to obtain estimates of population abundance and mortality rates using data through 1998. Sensitivity analyses included examination of various combinations of the three indices available for tuning (MRFSS, headboat, and commercial hook and line), truncation of the time series for the three indices to a period in which size limits were generally constant, examination of alternatives for the F ratios for the terminal age group (fixing or estimating F), examination of two alternative stock-recruitment relationships, and an examination of the assumed level of M (0.15, 0.25, 0.35).

The current VPA analyses (Brown et al. 2005; SEDAR9-AW10) maintained the base case configuration of the previous assessment with respect to M, F-ratios and stock-recruitment relationship. This "**<u>Continuity Case-VPA</u>**" was considered to be the equivalent of the model used in the previous assessment (Turner et al. 2000) and was to provide continuity between that assessment and the current assessment. The inputs to this model were the same as in the previous assessment with the exception of updated catch statistics.

In addition to the Continuity Case-VPA, four other VPA's were run with various options. <u>Option 1</u> was the same as the Continuity Case-VPA except that two additional abundance indices were used, including an index of the longline catch rate data and a fishery-independent index developed from SEAMAP reef fish video survey data. <u>Option 2</u> was the same as Option 1 except that the VPA run was performed with equal weighting among indices. Option 1, similar to the Continuity Case-VPA, had index values weighted by the coefficients of variation estimated in the standardization process (input variance weighting) but it was rationalized that the measures of uncertainty were not truly comparable between the indices. <u>Option 3</u> was identical to Option 2 except that the selectivity of the handline index was allowed to vary over time, rather than constraining it to be identical across the catch history (as in Option 2), which was reasonable given a size limit implementation. Option 4 was identical to Option 3 except for the age-slicing method used and hence the catch-at-age matrix used as input. The catch-at-age matrix used in the Continuity Case-VPA and Options 1-3 was calculated by applying monthly slicing limits, the same as those used in the previous assessment, to the catch-at-size data. These slicing limits were based upon the growth curve developed by Thompson et al. (1999), which assumed a birth date of June 1.

Unfortunately, there was insufficient size sample information to adequately create catch-at-size on a monthly basis. Instead, yearly size samples were applied to the corresponding catches. As it was considered inappropriate to apply month-specific age slicing limits to the catch-at-size, alternative yearly slicing limits were constructed for the Option 4-VPA. Furthermore, the birth date was assumed to be April 1, as this was the birth date assumed by Thompson et al. (1999) in developing the growth curve.

For the Continuity Case-VPA, weight-at-age inputs were the same as used for the previous assessment, calculated from the growth curve but corresponding to the weights-at-age at the end of the year. Since it was more appropriate to use mid-year weight-at-age, these were used for the Option 4-VPA. Mid-year and spawning weight-at-age were calculated assuming the April 1 birth date.

In summary, the Option 4-VPA model was an extension of the Continuity-VPA and used updated catch statistics, as in the Continuity Case-VPA, but used an alternative approach to age slicing to define catch-at-age, an alternative calculation of weight-at-age, time-variant selectivity in the handline index, and two additional indices to tune the VPA (longline fishery index and a fishery-independent video survey index). The Option 4-VPA was considered by the SEDAR9-AW to be the preferred option, hereafter referred to as the "**Preferred Case-VPA"**.

3.1.1.2. Data Sources

The catch-at-age matrix used for the Continuity Case-VPA is shown in Table 3.1.1.2.1 and in Figure 3.1.1.2.1. Applying the alternative slicing limits (Table 3.1.1.2.2), the resulting catch-at-age matrix used for the Preferred Case-VPA is shown in Table 3.1.1.2.3 and in Figure 3.1.1.2.2.

In addition to the fishery data, three indices were used in the Continuity Case-VPA (MFRSS, Headboat, and Commercial hook and line), and all five indices were used in the Preferred-Case VPA (inclusive of a commercial longline index and a SEAMAP reef fish index).

As in the previous assessment, a hockey-stick (piece-wise linear) stock recruitment relationship (Barrowman and Meyers 2000) was fit to the observed data. The biological parameters used as inputs to the VPA's are summarized in Table 3.1.1.2.4.

Based on the SEDAR9-DW, 20% of discarded greater amberjack were assumed to have died. This was the same as the 2000 assessment (Turner et al. 2000; Cummings and McClellan 2000).

3.1.1.3. Model Configuration and Equations

VPA's (Brown et al. 2005) were conducted using the program VPA-2box (Porch 1999). VPA-2box employs methods similar to the ADAPT approach (Powers and Restrepo 1992) to obtain estimates of population abundance and mortality rates. Details of this model are given in Turner et al. (2000) and http://www.iccat.es/AssessCatalog.htm.

3.1.1.4. Parameters Estimated

VPA-2box estimates F at age, N at age, spawning stock biomass, and recruitment (Brown et al. 2005). Once the final values have been identified, then the benchmarks can be calculated (Tables 3.1.2.2.1.a,b).

3.1.1.5. Uncertainty and Measures of Precision

Bootstrap estimates were produced for all VPA models and projection runs.

3.1.2 Model 1: Virtual Population Analysis Results

3.1.2.1. Measures of Overall Model Fit

The fits of the indices are shown in Figure 3.1.2.1.1 for the Continuity Case-VPA and Figure 3.1.2.1.2 for the Preferred Case-VPA. Details of the fits of the indices are given in Brown et al. (2005, Tables 7 & 12).

3.1.2.2. Parameter Estimates

The estimated benchmarks from the Continuity Case-VPA are shown in Table 3.1.2.2.1a and for the Preferred Case-VPA in Table 3.1.2.2.1b.

Projected yields for the Continuity Case-VPA are shown in Tables 3.1.2.2.2a and 3.1.2.2.3a, as well as Figure 3.1.2.2.1. Projected yields for the Preferred Case-VPA are shown in Tables 3.1.2.2.2b and 3.1.2.2.3b, as well as Figure 3.1.2.2.2.

Selected results from the Continuity Case-VPA are compared to those of the last assessment (using a VPA, Turner et al. 2000) in Figure 3.1.2.2.3.

3.1.2.3. Stock Abundance and Recruitment

The estimated abundance of each age class is shown in Table 3.1.2.3.1 (Continuity Case-VPA) and Table 3.1.2.3.2 (Preferred Case-VPA).

3.1.2.4. Stock Biomass (Total and Spawning Stock)

The spawning stock biomass estimates are shown in Table 3.1.2.4.1a and Table 3.1.2.4.1b for the Continuity Case-VPA and the Preferred Case-VPA, respectively. The dispersions of bootstrap estimates of current stock status are shown in Figure 3.1.2.4.1 (Continuity Case-VPA) and Figure 3.1.2.4.2 (Preferred Case-VPA).

3.1.2.5. Fishery Selectivity

The overall selectivity pattern estimated through VPA for the greater amberjack fisheries is compared to the selectivity pattern from SSASPM (See section 3.3) in Figure 3.1.2.5.1. In general, the VPA showed greater selectivity at younger age classes compared to SSASPM.

3.1.2.6. Fishing Mortality

The estimated fishing mortality rates are shown in Table 3.1.2.6.1 (Continuity Case-VPA) and Table 3.1.2.6.2 (Preferred Case-VPA).

3.1.2.7. Stock-Recruitment Parameters

The parameter values for the hockey-stick (piece-wise linear) stock recruitment relationship (Barrowman and Meyers 2000) were 314055 (maximum recruitment) and 163841 (spawning biomass scaling parameter). The estimated spawning biomass and recruitment are shown in Table 3.1.2.7.1 (Continuity Case-VPA) and Table 3.1.2.7.2 (Preferred Case-VPA).

3.1.2.8. Measures of Parameter Uncertainty

The measures of uncertainty are reported under each section, based upon the bootstrap runs.

3.1.2.9. Retrospective and Sensitivity Analyses

No retrospective analyses were conducted. VPA's (Options 2 & 3) (see section 3.1.1.1), alternatives to the Continuity Case-VPA, are discussed in detail in the VPA analysis supporting document (Brown et al. 2005).

3.2. Model 2: Surplus Production Model (ASPIC)

In the previous stock assessment (Turner et al. 2000), there was concern that the VPA relied on the catch at age matrix being known exactly when in fact the ages were inferred using the length composition using a growth curve (age-slicing, which is done by inserting fish lengths into an inverted von Bertalanffy growth model). This approach does not take into account the effects of different year-class strengths and mortality on the observed length distributions or the degree of overlap between the length distributions of adjacent age groups. Therefore, the length composition data may be insufficient to accurately estimate the degree of variability in length at age. In addition, the preferred growth curve of Thompson et al. (1999) covered various gear sectors but was restricted geographically to Louisiana and therefore not Gulf-wide. Preferably, age-length keys representative of all sectors and regions of the fishery would be used to ameliorate this concern but these keys are inadequate currently for greater amberjack in the Gulf. Since the catch-at-age matrix used in the VPA's may be inexact, a surplus production model was used because it does not require a catch-at-age matrix as input.

3.2.1. Model 2: Surplus Production Model (ASPIC) Methods

3.2.1.1. Overview

Version 5.10 of ASPIC was used to fit a non-equilibrium production model conditioned on yield to the Gulf of Mexico greater amberjack data (Diaz et al. 2005; SEDAR9-AW5-REV). ASPIC includes the possibility of including several data from several fisheries on the same stock and 'tunes' the model to one or more indices of abundance.

3.2.1.2. Data Sources

Table 3.2.1.2.1 shows the yield (including 20% discard mortality) and estimated indices of abundance by fishery used as input for ASPIC. The recreational charterboat-private boat fishery is the major contributor to the total landings of this species followed by the commercial handline fishery.

The catch-CPUE series analyzed with ASPIC corresponded only to the period 1986-2004 because the condition on yield used on the ASPIC model requires catch information for each fishery for every year, and yield for the charterboat fishery is not available prior to 1986.

3.2.1.3. Model Configuration and Equations

The initial investigation was to compare the generalized versus the logistic production model. The estimated value of the exponent by the generalized model (2.33) was not significantly different (P=0.3824) from the logistic model exponent (2), while the other estimated parameters B_1/K, MSY, and K were very similar. The result of this comparison was that the logistic model provided as good a fit as the generalized. Therefore, the more parsimonious model (the logistic) was selected for subsequent evaluations. All indices were equally weighted.

ASPIC requires initial values of B_1/K, MSY, K and selectivity *q* by fleet. All runs were performed allowing the program to estimate the parameters mentioned above.

3.2.1.4. Parameters Estimated

Using the logistic option, ASPIC estimates B_{MSY} as K/2 and F_{MSY} as MSY/B_{MSY}. Once the final values have been identified, then the benchmarks can be calculated.

3.2.1.5. Uncertainty and Measures of Precision

Bootstrap analyses were performed to estimate variability around the estimated parameters and projection analyses were also performed for different scenarios of F and for constant yield.

3.2.2. Model 2: Surplus Production Model (ASPIC) Results

3.2.2.1. Measures of Overall Model Fit

Initial runs of the production model ASPIC showed no convergence problems. Figure 3.2.2.1.1 shows the observed CPUE series for each fishery and the predicted values by ASPIC assuming a 20% release mortality.

3.2.2.2. Parameter Estimates

ASPIC estimated that in 1986 (the beginning of the time series) the greater amberjack stock was approximately 84% of the virgin level. MSY was estimated to be about 4.8 million lbs, B_{MSY} 9.9 million lbs and maximum population size K 19.9 million lbs. Estimated F_{MSY} was 0.48 and current relative F (F_{2004}/ F_{MSY}) was 1.02, current relative biomass (B_{2004}/ B_{MSY}) was estimated at 0.71. Table 3.2.2.2.1 summarizes all parameters estimated by ASPIC for the base model.

3.2.2.3. Stock Biomass

Virgin biomass (K) was estimated to be about 19.9 million lbs and B_{MSY} 9.94 million lbs (50% of K by definition). At the beginning of the time series, biomass B_{1986} was 16.7 million lbs and relative biomass B_{1986}/B_{MSY}=1.7 (Figure 3.2.2.3.1). Biomass declined from 1986 through 1998. The stock became overfished in 1990 with B_{1990}=6.4 million lbs and relative biomass=0.64. The lowest level of biomass was reached in 1998 (B_{1998}=2.7 million, B_{1998}/B_{MSY}=0.27). The stock showed a continuous period of recovery since then reaching a biomass of about 7 million lbs in 2004. However, the stock still remained overfished with a relative biomass B_{2004}/B_{MSY}=0.7 (Figure 3.2.2.3.1).

3.2.2.4. Fishing Mortality

ASPIC estimated F_{MSY}=0.48. The results of the surplus production model showed that the Gulf of Mexico greater amberjack stock has experienced overfishing conditions since at least 1986 (F_{1986}=0.50), with the exception of 1988 (F_{1988}/F_{MSY}=0.86) and 1990 (F_{1990}/F_{MSY}=0.84). Although variable, F remained relatively high until 1997 (F_{1997}=0.95) when a discernible declining trend started. Relative F reached the lowest value after 1997 in 2001 (F_{2001}/F_{MSY}=1.04), it increased during 2002 and 2003 and decreased in 2004 to a value of 1.02. Therefore, the stock still remained slightly overfished (Figure 3.2.2.3.2). Figure 3.2.2.3.1 shows the ASPIC estimated relative F trajectory.

3.2.2.5. Measures of Parameter Uncertainty

Initial runs with 1000 bootstraps showed no difference between the 10-90th and 50th percentiles when compared with 500 bootstrap run. Therefore, to reduce computation time 500 bootstraps were selected for the analysis. Figure 3.2.2.3.1 shows relative F (F/F_{MSY}) and relative biomass (B/B_{MSY}) with the estimated 10-90th percentiles.

3.2.2.6. Retrospective and Sensitivity Analyses

Sensitivities were run for three initial values of B_1/K (0.2, 0.5, 1.0) and two additional levels of discard mortality (0% and 40%), given that 20% discard mortality was chosen for the base case. ASPIC estimates of relative B and relative F showed little differences between the base model and the sensitivities (Figures 3.2.2.6.1 and 3.2.2.6.2).

Table 3.2.2.6.1 summarizes the estimated parameters for the base case and the sensitivities. ASPIC runs with starting conditions for B_1/K=1 for release mortality 20% and 40% did not produce feasible results ($B_1/K > 1$, total objective function approximately doubled the value of previous runs).

In general, the model reached similar values for the estimated parameters for all initial conditions and release mortalities. Estimated carrying capacity K ranged from 19.9 to 21.5 million lbs, while MSY ranged from 4.11 to 5.67 million lbs. In general, higher levels of release mortality resulted in higher estimates of K, MSY and F_{MSY} and lower estimates of B_{MSY}. By assuming a release mortality of 40% the stock biomass at the beginning of the time series (1986) should have been very close to the virgin biomass (K). Conversely, a 0% release mortality indicated that the stock biomass was approximately 68% of the virgin biomass in 1986. Basically, higher levels of release mortality resulted in higher yields that required B_1 to correspond to higher proportions of K. Similarly, the estimated relative biomass assuming 40% release mortality is larger than that estimated with lower release mortalities (i.e., 20% and 0%). This model result indicated that for higher levels of release mortality, the greater amberjack stock is required to have higher productivity to sustain the observed levels of yield. However, all the results obtained using the different levels of release mortality showed the same trend.

3.3. Model 3: State-Space Age-Structured Production Model (SSASPM)

The SSASPM represents a step-up in model complexity from the a surplus production model, such as ASPIC, because it can incorporate age-specific differences in model parameters such as growth, fecundity, and gear vulnerability (selectivity). In the case where there are multiple fisheries that exploit different age classes, having the flexibility to incorporate age-specific information could lead to a better fit to observation data.

3.3.1. Model 3: State-Space Age-Structured Production Model Methods

3.3.1.1. Overview

A Bayesian implementation of a State-Space Age-Structured Production Model (SSASPM) developed by Porch (2002) was applied to greater amberjack (Diaz et al. 2005; SEDAR9-AW5-REV). Currently, this age structure production model allows specification of age-specific vectors for fecundity, maturity, and selectivity. Length and weight at age are calculated within the model based on user-specified growth functions. In addition, one can specify or estimate a level of historical fishing with one of three trends (constant, linear or exponential) to be in equilibrium at that level of fishing.

3.3.1.2. Data Sources

Statistics of the commercial handline fishery extends back to 1963 while data for the commercial handline fishery are only available since 1979. In the case of the recreational fishery, landings of the headboat fishery are available from 1986 and from MRFSS since 1981. ‘Historical’ catches for the recreational sector were estimated for the period 1963-1980 (G. Scott, pers. comm.) assuming that the fishery evolved following a pattern similar to the handline fishery during the same period and as a function of coastal population size (Table 3.3.1.2.1). Greater amberjack catches of the longline fishery were assumed to be 100 lbs. prior to 1979.

3.3.1.3. Model Configuration and Equations

A thorough explanation of the SSASPM model and equations is given in Porch (SEDAR-RD17). Values of input parameters followed the selections made by the SEDAR9-DW (Table 3.3.1.3.1). Following Thompson et al. (1991), age 3 was selected as age of 50% maturity. Batch fecundity (BF) was estimated as a function of age as BF = 458.601 * Age + 254,065 (Harris at al. 2004). Although batch fecundity was used in the current assessment, any future assessment requiring an estimate of egg production would need to use total annual fecundity at age, which would be estimated from Harris (2004) as the batch fecundity multiplied by 12 (number of batches spawned over a spawning season). Sex ratio was assumed to be 1:1. The SEDAR9-DW recommended a prior density function on steepness be lognormal with a mode of 0.7. Fishery specific selectivity at age was estimated from length samples (all years combined). A natural mortality of 0.25 and 0% discard mortality were chosen as input values for the base model. Results from exploratory runs showed that the program behaved better if it estimated effort only for the period 1963-1967. This effort was estimated assuming a linear increase. Catches for the historic period 1963-1980 were down weighted compared to the rest of the catch series. Because there was no index reflecting the abundance of age 0 fish (e.g. shrimp bycatch data), all runs were performed without attempting to estimate any annual recruitment deviation.

3.3.1.4. Parameters Estimated

SSASPM estimates fishing mortality rates, yield, and spawning stock biomass. Once the final values have been identified, then the benchmarks can be calculated.

3.3.1.5. Uncertainty and Measures of Precision

The point estimates for model parameters obtained from each model run minimize the overall objective function. Likelihood profiling was used to characterize the uncertainty of α (maximum lifetime reproductive rate), R0 (virgin recruitment), and estimates of current spawning stock biomass (SSB_{2004}) and fishing mortality rate (F_{2004}).

3.3.2. Model 3: State-Space Age-Structured Production Model Results

3.3.2.1. Measures of Overall Model Fit

Initial runs of the SSASPM were performed assuming natural mortality M= 0.25 and 0.35). Generally, model runs performed adequately. Figure 3.3.2.1.1 shows the estimated and observed yield and CPUE series for the base model (M=0.25). Estimated yield showed a fairly good fit to the observed values. However, the fit to the indices of abundance was poor, particularly for the recreational fisheries.

3.3.2.2. Parameter estimates

SSASPM estimated parameters and relative benchmarks are presented in Table 3.3.2.2.1.

3.3.2.3. Stock Abundance and Recruitment

SSASPM estimated that stock abundance remained approximately constant from the initiation of the time series (1963 corresponded to the assumed virgin level) until the early 1980's, followed by a sharp decline that continued until 1995 when the stock was 50% of the virgin level. Afterwards, a period of recovery started and continued until early 2002 when the stock improved to 60% of the virgin level. Years 2003 and 2004 showed little change with respect to 2002. SSASPM estimated that recruits followed a similar trend as the stock biomass. Lowest estimated level of recruits was in 1996 and corresponded to 73% of the virgin level. The recovery period followed and in 2004 the level of recruits was 83% of the virgin level and 4% higher than recruitment at MSY.

3.3.2.4. Spawning Stock Biomass

SSASPM estimated at the virgin level, SSB_{virgin}=2.13E+11, while SSB_{MSY} was about 36% of SSB_{virgin} (SSB_{MSY}=7.65E+10) and SSB_{2004} was about 9% higher than SSB_{MSY} (SSB_{2004}=8.35E+10). Based on MSST [(1-M)*SSB_{MSY}], the greater amberjack stock approached an overfished condition in the mid-1990s (Figure 3.3.2.4.1) but has never exceeded the overfished threshold (Figure 3.3.2.4.2). The model estimated that the stock is currently almost 2/3 depleted (SSB_{2004}/SSB_{virgin}=0.36). Relative SSB to different benchmarks are presented in Table 3.3.2.2.1.

3.3.2.5. Fishing Mortality

SSASPM estimated fishing mortality F is presented in Figure 3.3.2.4.1. Estimated F_{MSY}=0.22 and current level of F_{2004}=0.21 (Table 3.3.2.2.1) indicated that the stock is currently not undergoing overfishing (Figure 3.3.2.4.2). Using F_{MSY} as a benchmark, overfishing conditions started in 1987 and continued until 1997, with the exception of 1988 and 1990 (Figure 3.3.2.4.1). Relative F remained approximately constant at ~0.75 from 1998 to 2001, followed by a significant increase in 2002 and 2003. Year 2004 showed a slight decline in relative F (F_{2004}/F_{MSY}=0.96). Relative F to different benchmarks is presented in Table 3.3.2.2.1.

3.3.2.6. Stock-Recruitment Parameters

SSASPM estimated a lower steepness (h=0.63) than the mean value of the prior (h=0.7). While this suggests that the data contained information that stock resiliency was lower than implied by the prior, the prior mode is contained within the 95% likelihood profile confidence interval.

3.3.2.7. Measures of Parameter Uncertainty

As mentioned in Section 3.3.1.5, uncertainty was examined by developing likelihood profiles for α (maximum lifetime reproductive rate), R0 (virgin recruitment), and for estimates of current spawning stock biomass (SSB_{2004}) and fishing mortality rate (F_{2004}). The prior on α was lognormal and the peak (9.33) corresponded to a steepness of 0.7, while the mode of the likelihood profile (6.2) corresponded to a steepness of 0.61. While this suggested that the data contained information that the stock resiliency was lower than implied by the prior, the prior mode was contained within the 95% likelihood profile confidence interval.

3.3.2.8. Retrospective and Sensitivity Analyses

Sensitivities were run for: 1) two additional levels of natural mortality (M=0.2 and M=0.35) with the same steepness prior (mean=0.7, CV=0.35) of the base model; 2) the base case natural mortality (M=0.25) and steepness prior with two different mean values (0.8 and 0.9); and 3) the natural mortality and steepness of the base model and age of 50% selectivity of each gear reduced by one year. Table 3.3.2.8.1 shows SSASPM estimated parameters for different levels of M and steepness. Sensitivities for different levels of natural mortality showed similar trends and stock status estimates (Figure 3.3.2.8.1). Overfishing conditions started in 1986 and the stock became overfished around 1991. Relative SSB showed that a period of recovery started around the mid 90's and overfishing did not occur after 1998. However, a decline in relative SSB was observed for the last two years of the series. Higher steepness implies greater stock resilience. At the upper limit a steepness of 1 would imply constant recruitment. The model showed that at higher steepness the status of the stock is better (Table 3.3.2.8.1). For example, for a steepness of 0.9, which implies a highly resilient stock, the model estimated that the stock was never overfished and never experienced overfishing (Figure 3.3.2.8.2). To test the sensitivity of the results to gear selectivity, an additional run was performed for the base case reducing the age at 50% selectivity of each gear by one year. The results (Figure 3.3.2.8.3) indicated that reducing the age at 50% selectivity did not change the relative SSB and F trends. However, unlike the original selectivity, the alternative selectivity shows a scenario where the stock did not recover from its overfished condition and overfishing still occurs.

4. Models Comparison

4.1. Compare and Contrast Models Considered

The Continuity Case-VPA and Preferred Case-VPA both indicated that greater amberjack are overfished and that overfishing is still occurring in 2004 (Figures 3.1.2.4.1 and 3.1.2.4.2).

Overall, both VPA's estimated $F_{2004}/F_{30\text{-}40\%SPR}$ to be 2.12-4.70 (Tables 3.1.2.2.1a,b) and $SSB_{2004}/SSB_{30\text{-}40\%SPR}$ to be 0.29-0.44 (Tables 3.1.2.2.1a,b). The accuracy of the VPA results were questioned, however, since the catch-at-age matrix is not known exactly due to reliance on assigning fish to an age based on their length using a compromised age-slicing method.

Based on the ASPIC model, the greater amberjack stock has experienced overfishing ($F/F_{MSY} > 1.0$) conditions since at least 1986 (except 1988 and 1990) and it has been overfished ($B/B_{MSY} < 0.75$) since 1990 (Figure 3.2.2.3.1). Relative SSB showed that a period of recovery started in 1998, two years after the implementation of the one fish bag limit for the recreational fishery. Although the recovery period continued until the present, the greater amberjack stock still remains overfished and overfishing is still occurring (Figure 3.2.2.3.2).

Based on SSASPM, overfishing conditions began in 1986 and persisted through 1997 (except 1988 and 1990) but the stock was not undergoing overfishing in 2004 (Figure 3.3.2.4.2). In addition, SSASPM results indicated that the greater amberjack stock has never been overfished through the period of 1963 to 2004 (Figure 3.3.2.4.2).

4.2. Preferred Model Recommendation

The SEDAR9-AW preferred the use of ASPIC, the non-equilibrium production model, for assessing the stock status of greater amberjack in the Gulf of Mexico. This was primarily due to the VPA and SSASPM being reliant on a catch-at-age matrix or age-specific vectors, respectively, when there was considerable uncertainty in assigning age to amberjack using an age-slicing approach. Differences between the selectivity patterns estimated by VPA and SSASPM were also considerable for ages 1-3 (Figure 3.1.2.5.1). Whereas the Preferred Case-VPA indicated that the greater amberjack stock was undergoing overfishing and was overfished in 2004 (Figure 3.1.2.4.2), SSASPM indicated that the stock had never been overfished and that overfishing was not occurring in 2004 (Figure 3.3.2.4.2). The divergent status of the stock based on these latter two models further indicated problems in relying on a stock assessment model based on age-specific parameters, since they currently may not be well enough defined for the greater amberjack stock in the U.S. Gulf of Mexico.

5. Biological Reference Points (SFA Parameters)

5.1. Existing Definitions and Standards

Status determination criteria include a Minimum Stock Size Threshold (MSST), i.e., the overfished criterion, and a Maximum Fishing Mortality Threshold (MFMT), i.e., the overfishing criterion.

Amendment 22 (May 2004) of the Gulf Council's Reef Fish Fishery Management Plan provides the preferred definitions of the overfishing criterion (MFMT) and overfished criterion (MSST) for the Gulf of Mexico reef fish stocks. Within that amendment, MSST is defined as: (1-M) *B_{MSY}, where M is the adult natural mortality rate (M=0.25) of greater amberjack, and greater amberjack MFMT is equal to F_{MSY}. As such, the greater amberjack stock would be considered undergoing overfishing if F_{CURR} is greater than MFMT (F_{MSY}) and the greater amberjack stock would be considered overfished if B_{CURR} is less than MSST.

For overfished stocks, a recovery plan must be developed to end overfishing and restore the stock to the biomass level (B_{MSY}) capable of producing maximum sustainable yield (MSY) on a continuing basis. Rebuilding is to occur in as short a time period as possible, but should not exceed 10 years unless conditions dictate otherwise.

5.2. Results

5.2.1. Overfishing Definitions and Recommendations

Under the Council's preferred definition for MFMT (overfishing criterion), the greater amberjack resource in the U.S. Gulf of Mexico is still considered to be undergoing overfishing, with F_{2004}/F_{msy} = 1.017, therefore exceeding the MFMT (Figure 3.2.2.3.2).

5.2.2. Overfished Definitions and Recommendations

Under the Council's preferred definition for MSST (overfished criterion), the greater amberjack resource in the U.S. Gulf of Mexico is considered to be overfished, with B_{2004} /B_{msy} = 0.706, where MSST = 0.75B_{msy} (Figure 3.2.2.3.2).

5.2.3. Control Rule and Recommendations

Greater amberjack in the Gulf of Mexico are under a rebuilding plan implemented in June 2003 under Secretarial Amendment 2. The rebuilding time period is specified as 7 years, with year one specified as 2003. Progress toward the rebuilding goal is addressed in Section 6.3.1 below.

6. Projections and Management Impacts

6.1. Projection Methods and Assumptions

Using ASPIC, the case of 20% release mortality and an initial value of B_1/K=0.5 was chosen for bootstrap (500 runs) and projection analysis. Relative biomass projections for the years 2005-2020 were obtained for 1) different scenarios of future F/F_{2004} (values from 0.5 to 1 by 0.1 intervals) and 2) by keeping the 2004 catch constant (yield + 20% discards).

6.2. Projection Results

The estimated relative biomass (B/B_{MSY}) with the 10^{th}-90^{th} percentiles of the bootstrap, as well as projected values under different values of F/F_{2004}, are shown in Figure 6.2.1., with projections in Table 6.2.1. Projections indicate that the greater amberjack stock will not recover to B_{MSY} at current F within year 2020 (B_{2020}/B_{MSY}= 0.98). Recovery to B_{MSY} could occur between 2006 and 2008 depending on the reduction of fishing mortality from its current level (F=0.49) (i.e., in the year 2008 with an F of 90% of F_{2004}) (Table 6.2.1). Figure 6.2.2 presents the control rule plot for $F_{2005-2020}=F_{2004}$ (status quo F scenario), indicating that under the current estimated levels of F that the greater amberjack stock is projected to remain overfished and overfishing is projected to continue. Table 6.2.2 presents projected yields under different scenarios of constant F/F_{2004}.

Projections under constant yield showed a more optimistic view and if the current catch (yield + 20% discard mortality) of 3.67 million lbs is kept constant, then the greater amberjack stock is projected to recover from the overfished condition by the year 2007 (Figure 6.2.3) and overfishing will not occur after 2004 (Figure 6.2.4). The recovery is projected to reach a plateau at a relative biomass of 1.48 by the year 2017.

6.3 Past Regulatory Actions and Impacts

6.3.1. Evaluation of the Rebuilding Plan

The greater amberjack stock in the U.S. Gulf of Mexico is not predicted to recover to B_{MSY}, nor is overfishing predicted to be curtailed, within the timeframe of the current rebuilding plan (year 2010) based on projections of current exploitation (F). The goal of rebuilding the stock by 2010 can be obtained by reducing F to 90% of current F; under such a scenario biomass will exceed the rebuilding target (i.e., B/B_{MSY} >1) in 2008 (Table 3.2.2.8.1). Alternatively, the biomass rebuilding target (Bmsy) can be achieved by 2007 under a constant current catch strategy (Figure 6.2.3).

7. Research Recommendations

- age-length keys representative of all sectors and regions of the fishery in the U.S. Gulf of Mexico (in part being addressed by current MARFIN NA05NMF4331071).

- reproductive parameters, such as age of sexual maturity and fecundity at age for the Gulf of Mexico stock of amberjack (age at maturity being addressed by current MARFIN NA05NMF4331071).

- fishery-specific release mortality

8. Literature Cited

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Figure 3.1.2.1.2. Fits of abundance indices (left) and the selectivity patterns (right) for the Preferred Case-VPA (Option 4). NOTE: The graph in the lower right is not the selectivity pattern for the SEAMAP index (which was assumed to be evenly selected across ages), but rather it is the headboat selectivity pattern in 1988.

Figure 3.1.2.2.1. Cumulative frequency distribution of predicted future yields from the Continuity Case-VPA results under F30% and F40% for 2007, 2008 and 2009.

Figure 3.1.2.2.2. Cumulative frequency distribution of predicted future yields from the Preferred Case-VPA (Option 4) results under F30% and F40% for 2007, 2008 and 2009.

Figure 3.1.2.2.3. Comparison of selected results from Continuity Case-VPA to VPA results from the 2000 assessment.

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Figure 3.1.2.4.2. Estimates of stock status in the terminal year based on 501 bootstrap results for the Preferred Case-VPA (Option 4). Open red circle represents the deterministic outcome. The solid red line represents an MFMT control rule and the solid green line represents an OY target control rule.

Figure 3.1.2.5.1. Comparison of the selectivity patterns estimated by VPA and SSASPM.

Figure 3.2.2.1.1. ASPIC estimated and observed CPUE series for the commercial handline (HL), longline (LL), recreational headboat (HB) and charterboat-private boat (CB+PB) fisheries.

Figure 3.2.2.3.1. ASPIC estimated relative biomass (B/B_{MSY}) and relative F (F/F_{MSY}) trajectories assuming 20% discard mortality. Dashed lines correspond to 10-90th percentiles.

Figure 3.2.2.3.2. Status of greater amberjack with respect to F/Fmsy and B/Bmsy for ASPIC. The limit and threshold control rules are shown by dashed lines.

Figure 3.2.2.6.1. ASPIC estimated relative F (F/F_{MSY}) and relative biomass (B/B_{MSY}) for three levels of discard mortality. Dashed lines correspond to estimated 10-90th percentiles for the base case (20% discard mortality).

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Figure 3.3.2.4.2. Status of greater amberjack with respect to F/Fmsy and SSB/SSBmsy based on SSASPM. The limit and threshold control rules are shown by dashed lines.

Figure 3.3.2.8.1. SSASPM estimated relative SSB (SSB/SSB_{MSY}) (solid lines) and relative F (F/F_{MSY}) (dashed lines) for base case (M=0.25) and two other levels of natural mortality (M=0.2, M=0.35).

Figure 3.3.2.8.2. SSASPM estimated relative SSB (SSB/SSB_{MSY}) (solid lines) and relative F (F/F_{MSY}) (dashed lines) for three levels for the steepness prior (M=0.25).

Figure 3.3.2.8.3. SSASPM estimated relative SSB (SSB/SSB_{MSY}) (solid lines) and relative F (F/F_{MSY}) (dashed lines) for two different gear selectivities.

Figure 6.2.1. ASPIC estimated relative biomass (B/B_{msy}) and projected values for different constant values of F/F_{2004}.

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Figure 6.2.3. ASPIC estimated projected relative biomass (B/B_{MSY}) for constant values of catch for 2005-2019. Dashed lines correspond to 10-90th percentiles of bootstrap.

Figure 6.2.4. ASPIC estimated projected relative F (F/F_{MSY}) for constant values of catch for 2005-2019. Dashed lines correspond to 10-90th percentiles of bootstrap.

Table 3.1.1.2.1. Catch-at-age (numbers) used in the Continuity Case-VPA.

Year	Age 0	1	2	3	4	5+
1987	130751	249214	123367	56446	20499	29879
1988	89205	223268	176072	52855	18260	22629
1989	86820	224426	99856	97260	43279	43686
1990	28795	47513	36357	27664	18736	19775
1991	21847	76853	136509	94833	21427	25490
1992	17285	39515	134388	85111	19777	15248
1993	17603	53162	86816	97076	49583	25571
1994	19534	41502	74783	69807	26389	25941
1995	23588	41295	65082	35615	23545	13402
1996	10506	32226	92495	63800	23168	16107
1997	15213	28193	30310	28726	17306	11032
1998	15522	33122	43889	21727	11836	13834
1999	15250	30769	45329	16358	5666	12752
2000	32362	51476	76365	38104	16777	9018
2001	132444	170716	171961	26685	12048	16130
2002	68392	93485	160457	59266	17087	12992
2003	64681	89895	176721	66146	28287	16929
2004	42199	68573	118412	64474	36419	16002

Table 3.1.1.2.2. New yearly age-slicing limits (cm, fork length, integer value).

Age Class	lower limit	upper limit
0	0	43
1	44	64
2	65	80
3	81	93
4	94	103
5+	104	Infinity

Table 3.1.1.2.3. Catch-at-age used for the Preferred Case-VPA.

	Age					
Year	0	1	2	3	4	5+
1987	125230	277383	105245	52868	21164	28274
1988	102275	261124	150179	28024	20288	20399
1989	101156	226032	107564	83867	34608	42105
1990	32434	45666	36565	25766	18710	19287
1991	32658	74672	178331	50353	16787	24156
1992	22508	39647	175442	42273	16850	14509
1993	22836	52596	96665	101003	34190	22300
1994	24285	40463	90713	56562	22288	23609
1995	27397	40395	67221	31474	23407	12520
1996	12516	33236	116783	35862	24945	14799
1997	19282	26823	30772	27778	15207	10888
1998	26245	31391	38636	18339	12093	13168
1999	23462	29041	45909	9607	5877	12122
2000	44919	49117	69827	36118	15213	8722
2001	184311	152308	148384	18040	12340	14582
2002	92070	87545	164871	42603	12162	12028
2003	88269	84824	175732	51269	26789	15550
2004	64525	64152	110559	57753	35450	13289

Table 3.1.1.2.4. Biological parameters used for VPA and projection runs.

<table>
<tr><td>Natural mortality</td><td>Assumed to be 0.25 for all ages</td></tr>
<tr><td>Assumed “birth date” of age 0 fish</td><td>Continuity Case: June
Preferred Case/Option 4: April 1 (also approximate mid-point of the peak spawning season)</td></tr>
<tr><td>Plus group</td><td>Age 5+</td></tr>
<tr><td>Growth rates</td><td>Length at age was calculated from the Thompson et al. (1999) growth equation:

$FL_{(cm)} = 138.9 * (1 - \exp^{(-0.246 * (t-(-0.79)))})$</td></tr>
<tr><td>Weights at age</td><td>Average weights-at-age were based on the Thompson et al. (1999) growth equation and the Manooch and Potts (1997) length-weight relationship:

$W_{(kg)} = 5.3 \times 10^{-8} *(L_{(cm)} * 10)^{2.976}$

For historical catches only, the following values were used:
<table>
<tr><td>age</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5+</td></tr>
<tr><td>$weight_{(lbs)}$ (mid-year and peak spawning, Continuity Case[1])</td><td>2.04</td><td>7.42</td><td>15.13</td><td>23.8</td><td>32.43</td><td>47.43</td></tr>
<tr><td>$weight_{(lbs)}$ (mid-year, Preferred Case/Option 4[2])</td><td>0.98</td><td>5.30</td><td>12.39</td><td>20.87</td><td>29.60</td><td>45.17</td></tr>
<tr><td>$weight_{(lbs)}$ (peak spawning, Preferred Case/Option 4[2])</td><td>0.61</td><td>4.35</td><td>11.07</td><td>19.41</td><td>28.16</td><td>43.59</td></tr>
</table>
[1] Continuity Case calculated predicted length using a birth date of Jan 1.
[2] Preferred Case/Option 4 calculated predicted length using a birth date of April 1.</td></tr>
<tr><td>Maturity schedule</td><td>
<table>
<tr><td>age</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5+</td></tr>
<tr><td></td><td>0</td><td>0</td><td>0</td><td>0.5</td><td>1.0</td><td>1.0</td></tr>
</table></td></tr>
<tr><td>Fecundity at age</td><td>Weight at age is used as a proxy for fecundity at age</td></tr>
</table>

Table 3.1.2.2.1a. Continuity Case-VPA benchmarks.

ref:	F2004	Fmax	F0.1	F20%	F30%	F40%
	0.669	0.285	0.170	0.279	0.196	0.142
F2004/ref	1	2.34	3.93	2.39	3.41	4.70
Fcurrent	0.605					
Fcurrent/ref	1	2.12	3.55	2.16	3.08	4.25
ref:	SSB2004	SSBmax	SSB0.1	SSB20%	SSB30%	SSB40%
	5219	8729	15350	8972	13410	17870
SSB2004/ref	1	0.60	0.34	0.58	0.39	0.29

Table 3.1.2.2.1b. Preferred Case-VPA (Option 4) benchmarks.

ref:	F2004	Fmax	F0.1	F20%	F30%	F40%
	0.522	0.330	0.209	0.349	0.247	0.181
F2004/ref	1	1.58	2.50	1.50	2.12	2.89
Fcurrent	0.548					
Fcurrent/ref	1	1.662	2.626	1.571	2.221	3.034
ref:	SSB2004	SSBmax	SSB0.1	SSB20%	SSB30%	SSB40%
	5877	9479	15530	8815	13210	17560
SSB2004/ref	1	0.62	0.38	0.67	0.44	0.33

Table 3.1.2.2.1a. Projected yield (lbs) based on the Continuity case-VPA for 2007-2009.

Scenario	Percentile	Year 2007	2008	2009
F30%	10th	290,900	505,200	666,400
	25th	410,500	661,200	907,000
	Median	656,600	1,085,000	1,448,000
	75th	1,159,000	1,636,000	2,212,000
	90th	1,920,000	2,516,000	3,100,000
F40%	10th	214,700	387,500	530,300
	25th	302,800	514,500	721,200
	Median	487,700	831,700	1,148,000
	75th	856,400	1,260,000	1,751,000
	90th	1,416,000	1,923,000	2,450,000

Table 3.1.2.2.1b. Projected yield (lbs) based on the Preferred case-VPA (Option 4) for 2007-2009.

Scenario	Percentile	Year 2007	2008	2009
F30%	10th	362,200	500,900	657,600
	25th	568,500	848,400	1,131,000
	Median	1,181,000	1,520,000	1,890,000
	75th	2,239,000	2,511,000	2,913,000
	90th	3,552,000	3,731,000	4,108,000
F40%	10th	271,700	386,700	535,200
	25th	425,100	658,700	913,500
	Median	879,200	1,180,000	1,518,000
	75th	1,654,000	1,957,000	2,353,000
	90th	2,619,000	2,895,000	3,287,000

Table 3.1.2.2.3a. Projected yield (in thousands of lbs) for the Continuity case-VPA.

	F30% scenario			F40% scenario		
	10th percentile	median	90th percentile	10th percentile	Median	90th percentile
2007	289	657	1,936	214	488	1,432
2008	495	1,085	2,519	378	832	1,943
2009	662	1,448	3,123	530	1,148	2,472
2010	908	1,899	3,562	747	1,560	2,906
2011	1,287	2,337	4,181	1,054	1,971	3,460
2012	1,665	2,786	4,578	1,409	2,368	3,862
2013	1,981	3,114	5,019	1,717	2,683	4,320
2014	2,211	3,334	5,422	1,930	2,926	4,642
2015	2,380	3,501	5,571	2,089	3,075	4,870
2016	2,579	3,639	5,634	2,318	3,220	5,025
2017	2,661	3,779	5,660	2,392	3,373	5,014
2018	2,767	3,935	5,837	2,490	3,534	5,111
2019	2,751	3,990	5,751	2,516	3,573	5,126
2020	2,817	4,060	5,962	2,608	3,650	5,232
2021	2,919	4,062	5,847	2,679	3,700	5,365
2022	2,945	4,035	5,778	2,744	3,691	5,201
2023	3,004	4,028	5,923	2,762	3,683	5,359
2024	2,984	4,049	5,904	2,804	3,709	5,366
2025	3,019	4,135	5,795	2,781	3,808	5,242
2026	2,875	4,100	5,823	2,740	3,758	5,195

Table 3.1.2.2.3b. Projected yield (in thousands of lbs) for the Preferred case-VPA.

	F30% scenario			F40% scenario		
	10th percentile	median	90th percentile	10th percentile	median	90th percentile
2007	359	1,181	3,635	268	879	2,683
2008	500	1,520	3,737	387	1,180	2,904
2009	650	1,890	4,112	527	1,518	3,312
2010	939	2,181	4,215	801	1,806	3,478
2011	1,327	2,621	4,525	1,134	2,186	3,831
2012	1,631	2,871	4,572	1,406	2,477	3,911
2013	1,850	3,051	4,730	1,603	2,665	4,201
2014	2,054	3,196	4,915	1,811	2,826	4,353
2015	2,158	3,309	4,904	1,936	2,979	4,371
2016	2,227	3,359	4,961	2,014	3,036	4,474
2017	2,341	3,377	5,124	2,147	3,063	4,588
2018	2,433	3,464	5,324	2,234	3,164	4,806
2019	2,415	3,551	5,205	2,239	3,258	4,672
2020	2,458	3,565	5,494	2,297	3,270	4,956
2021	2,491	3,573	5,341	2,306	3,296	4,822
2022	2,486	3,574	5,254	2,341	3,314	4,840
2023	2,572	3,542	5,227	2,404	3,302	4,773
2024	2,631	3,579	5,260	2,438	3,317	4,780
2025	2,629	3,633	5,145	2,452	3,366	4,720
2026	2,570	3,642	5,073	2,426	3,345	4,699

Table 3.1.2.3.1. Abundance at the beginning of the year for the Continuity case-VPA.

	Age					
Year	0	1	2	3	4	5+
1987	852998	833026	358243	154410	69016	100596
1988	871339	549681	431250	171498	71107	88120
1989	882588	600282	234003	182808	87446	88268
1990	754508	611126	272153	95510	58310	61543
1991	558314	562290	434204	180059	50230	59755
1992	459561	415602	370500	219077	58244	44906
1993	497141	342707	288971	171521	96577	49807
1994	421896	371694	220293	149281	49832	48986
1995	229951	311397	253047	106387	55737	31726
1996	325358	158377	206290	140191	51809	36019
1997	329497	244148	95131	80396	53834	34317
1998	395718	243237	165399	47651	37593	43939
1999	725765	294537	160380	90463	18263	41104
2000	996546	551808	202373	85320	56122	30167
2001	989320	747645	384543	91147	33379	44689
2002	653153	654303	432923	150253	47689	36260
2003	524544	448635	427584	197477	65472	39183
2004	308711	351758	270691	179421	96136	42241
2005		203410	213900	108012	83583	62149

Table 3.1.2.3.2. Abundance at the beginning of the year for the Preferred case-VPA.

	Age					
Year	0	1	2	3	4	5+
1987	887842	805169	280014	162426	68143	91036
1988	766157	581618	385355	126474	80397	80837
1989	806527	506964	226377	169476	73978	90003
1990	819361	539366	198660	83075	59367	61198
1991	551773	609600	379948	122687	42219	60752
1992	493885	401015	409235	141301	51784	44589
1993	423445	364849	277500	166340	73150	47711
1994	468538	309704	238020	131897	42622	45148
1995	231079	343550	205699	106433	53597	28668
1996	289690	155921	232107	101586	55417	32877
1997	336942	214606	92343	79682	47875	34278
1998	349518	245461	143601	45091	37855	41220
1999	656885	249146	163624	78081	19175	39551
2000	1038722	490947	168548	87336	52380	30031
2001	1030468	769462	339224	70584	36629	43284
2002	727552	641053	465895	135365	39203	38771
2003	669971	485834	422462	219221	68259	39622
2004	573170	444337	304044	176309	125887	47191
2005		389750	289791	140519	86954	92228

Table 3.1.2.4.1a. Projected SSB/SSB_{40} for the Continuity case-VPA.

Year	F30% scenario			F40% scenario		
	10th percentile	Median	90th percentile	10th percentile	Median	90th percentile
2007	0.03	0.07	0.28	0.03	0.07	0.29
2008	0.05	0.12	0.39	0.06	0.12	0.42
2009	0.11	0.23	0.56	0.12	0.26	0.63
2010	0.15	0.34	0.71	0.18	0.40	0.83
2011	0.19	0.42	0.81	0.23	0.50	0.98
2012	0.27	0.52	0.93	0.33	0.64	1.13
2013	0.37	0.63	1.05	0.47	0.77	1.31
2014	0.45	0.69	1.13	0.58	0.87	1.42
2015	0.50	0.76	1.19	0.64	0.96	1.51
2016	0.52	0.80	1.27	0.67	1.02	1.63
2017	0.56	0.82	1.32	0.74	1.06	1.68
2018	0.58	0.84	1.29	0.77	1.09	1.70
2019	0.61	0.88	1.28	0.80	1.15	1.66
2020	0.62	0.89	1.29	0.82	1.17	1.67
2021	0.62	0.91	1.29	0.82	1.19	1.72
2022	0.64	0.91	1.34	0.86	1.21	1.75
2023	0.64	0.90	1.34	0.86	1.20	1.74
2024	0.65	0.89	1.34	0.88	1.19	1.73
2025	0.66	0.90	1.32	0.90	1.19	1.75
2026	0.66	0.90	1.32	0.90	1.21	1.73

Table 3.1.2.4.1b. Projected SSB/SSB40 for the Preferred case-VPA.

Year	F30% scenario			F40% scenario		
	10th percentile	Median	90th percentile	10th percentile	median	90th percentile
2007	0.04	0.20	0.74	0.04	0.20	0.76
2008	0.07	0.27	0.84	0.07	0.28	0.90
2009	0.11	0.35	0.90	0.13	0.40	1.01
2010	0.16	0.47	0.98	0.18	0.54	1.15
2011	0.22	0.54	1.04	0.26	0.65	1.24
2012	0.32	0.63	1.05	0.39	0.77	1.29
2013	0.41	0.70	1.11	0.52	0.88	1.38
2014	0.47	0.76	1.17	0.60	0.98	1.48
2015	0.51	0.82	1.19	0.67	1.05	1.53
2016	0.54	0.83	1.28	0.71	1.08	1.61
2017	0.57	0.85	1.33	0.75	1.10	1.71
2018	0.59	0.86	1.31	0.78	1.12	1.70
2019	0.62	0.88	1.29	0.83	1.15	1.67
2020	0.63	0.90	1.29	0.83	1.18	1.69
2021	0.63	0.90	1.30	0.84	1.19	1.70
2022	0.65	0.91	1.34	0.86	1.21	1.75
2023	0.65	0.90	1.32	0.88	1.20	1.71
2024	0.65	0.90	1.33	0.88	1.19	1.73
2025	0.66	0.90	1.31	0.90	1.20	1.73
2026	0.67	0.90	1.31	0.90	1.21	1.73

Table 3.1.2.6.1. Fishing mortality rates for the Continuity case-VPA.

	Age					
Year	0	1	2	3	4	5+
1987	0.189	0.408	0.487	0.525	0.405	0.405
1988	0.123	0.604	0.608	0.424	0.34	0.34
1989	0.118	0.541	0.646	0.893	0.799	0.799
1990	0.044	0.092	0.163	0.393	0.446	0.446
1991	0.045	0.167	0.434	0.879	0.646	0.646
1992	0.043	0.113	0.52	0.569	0.478	0.478
1993	0.041	0.192	0.41	0.986	0.845	0.845
1994	0.054	0.134	0.478	0.735	0.886	0.886
1995	0.123	0.162	0.341	0.47	0.637	0.637
1996	0.037	0.26	0.692	0.707	0.69	0.69
1997	0.054	0.139	0.441	0.51	0.446	0.446
1998	0.045	0.166	0.353	0.709	0.435	0.435
1999	0.024	0.125	0.381	0.227	0.427	0.427
2000	0.037	0.111	0.548	0.688	0.408	0.408
2001	0.163	0.296	0.69	0.398	0.517	0.517
2002	0.126	0.175	0.535	0.581	0.512	0.512
2003	0.15	0.255	0.618	0.47	0.657	0.657
2004	0.167	0.247	0.669	0.514	0.55	0.55

Table 3.1.2.6.2. Fishing mortality rates for the Preferred case-VPA.

	Age					
Year	0	1	2	3	4	5+
1987	0.173	0.487	0.545	0.453	0.428	0.428
1988	0.163	0.694	0.571	0.286	0.333	0.333
1989	0.152	0.687	0.752	0.799	0.736	0.736
1990	0.046	0.1	0.232	0.427	0.435	0.435
1991	0.069	0.149	0.739	0.613	0.587	0.587
1992	0.053	0.118	0.65	0.408	0.453	0.453
1993	0.063	0.177	0.494	1.112	0.735	0.735
1994	0.06	0.159	0.555	0.651	0.869	0.869
1995	0.143	0.142	0.456	0.403	0.667	0.667
1996	0.05	0.274	0.819	0.502	0.696	0.696
1997	0.067	0.152	0.467	0.494	0.44	0.44
1998	0.089	0.156	0.359	0.605	0.443	0.443
1999	0.041	0.141	0.378	0.149	0.421	0.421
2000	0.05	0.12	0.62	0.619	0.394	0.394
2001	0.225	0.252	0.669	0.338	0.473	0.473
2002	0.154	0.167	0.504	0.435	0.427	0.427
2003	0.161	0.219	0.624	0.305	0.577	0.577
2004	0.136	0.177	0.522	0.457	0.379	0.379

Table 3.1.2.7.1. Spawning stock fecundity and recruitment for the Continuity case-VPA.

year	spawning biomass	recruits from VPA
1987	6662.	852998.
1988	6610.	871339.
1989	5884.	882588.
1990	4466.	754508.
1991	4409.	558314.
1992	4818.	459561.
1993	4699.	497141.
1994	3630.	421896.
1995	3225.	229951.
1996	3409.	325358.
1997	3219.	329497.
1998	2862.	395718.
1999	2798.	725765.
2000	3156.	996546.
2001	3153.	989320.
2002	3641.	653153.
2003	4467.	524544.
2004	5219.	308711.

Table 3.1.2.7.2. Spawning stock fecundity and recruitment for the Preferred case-VPA (Option 4).

year	spawning biomass	recruits from VPA
1987	5886.	887842.
1988	5786.	766157.
1989	5291.	806527.
1990	4052.	819361.
1991	3712.	551773.
1992	3767.	493885.
1993	3851.	423445.
1994	3017.	468538.
1995	2812.	231079.
1996	2882.	289690.
1997	2835.	336942.
1998	2564.	349518.
1999	2470.	656885.
2000	2857.	1038722.
2001	2825.	1030468.
2002	3258.	727552.
2003	4515.	669971.
2004	5877.	573170.

Table 3.2.1.2.1. Greater amberjack yield (including 20% discard mortality) and estimated indices of abundance for the recreational charterboat-private boat (CB+PB), recreational headboat (HB), commercial handline (HL) and longline (LL) fisheries used as input for ASPIC.

	CB+PB		HB		HL		LL	
	Index	Yield	Index	Yield	Index	Yield	Index	Yield
1986	1.925	5,124,193	2.641	694,998		1,333,090		213,781
1987	1.952	4,664,941	1.179	362,058		1,900,455		271,309
1988	1.243	1,383,742	1.256	210,814		2,522,088		349721
1989	2.911	6,022,928	1.705	247,605		2,413,920		321,830
1990	0.459	1,010,308	0.718	189,954		1,601,474		135,509
1991	1.716	3,687,417	0.564	127,840		2,020,019		6,577
1992	1.472	2,509,589	0.654	340,667		1,388,103		54,733
1993	0.885	3,045,696	0.462	253,723	1.071	2,197,766	0.751	87,012
1994	0.696	2,149,369	0.449	219,087	0.968	1,772,346	0.731	74,705
1995	0.473	778,617	0.718	146,621	1.191	1,736,856	0.927	89,020
1996	0.446	1,407,816	0.513	157,637	0.984	1,785,278	0.626	61,778
1997	0.304	984,974	0.500	126,239	0.764	1,557,058	0.793	64,614
1998	0.277	745,553	0.564	101,582	0.743	949,902	0.725	59,659
1999	0.371	893,017	0.551	85,133	0.877	1,054,547	0.700	65,731
2000	0.547	1,067,442	0.705	99,936	0.889	1,256,012	0.845	76,667
2001	0.588	1,699,666	1.179	103,329	0.956	1,011,507	0.907	52,392
2002	1.182	2,178,511	1.513	213,714	0.909	1,051,417	1.453	84,584
2003	1.033	2,720,301	1.397	201,991	1.367	1,288,963	1.604	136,510
2004	0.520	2,184,881	1.731	111,152	1.280	1,287,059	1.939	89,664

Table 3.2.2.2.1. Estimated parameters by ASPIC, q corresponds to estimated selectivities for the commercial handline (HL), longline (LL), recreational headboat (HB) and charterboat-private boat fisheries (CB+PB).

Parameter	**Estimate**
B1/K	0.840
MSY	4.815E+06
K	1.987E+07
q HL	2.15E-07
q LL	2.04E-07
q HB	1.47E-07
q CB+PB	1.35E-07
Bmsy	9.937E+06
Fmsy	0.484
B/Bmsy	0.706
F/Fmsy	1.02

Table 3.2.2.6.1. ASPIC estimated parameters for three different initial values of B_1/K and three different levels of discard mortality.

Assumed release mortality	Estimated parameters	Initial input value of B_1/K		
		1.0	0.5	0.2
0%	B_1/K	0.726	0.683	0.664
	MSY	4.113E+06	4.250E+06	4.295E+06
	K	2.025E+07	2.011 E+07	2.037 E+07
	B_{MSY}	1.012 E+07	1.006 E+07	1.018 E+07
	F_{MSY}	0.406	0.422	0.422
	B_{2004}/B_{MSY}	0.641	0.618	0.610
	F_{2004}/F_{MSY}	0.890	0.894	1.122
20%	B_1/K		0.840	0.839
	MSY		4.815 E+06	4.815 E+06
	K		1.987 E+07	1.990 E+07
	B_{MSY}		9.937 E+06	9.948 E+06
	F_{MSY}		0.485	0.484
	B_{2004}/B_{MSY}		0.706	0.691
	F_{2004}/F_{MSY}		1.017	0.961
40%	B_1/K		0.984	0.810
	MSY		5.456 E+06	5.671 E+06
	K		2.075 E+07	2.153 E+07
	B_{MSY}		1.038 E+07	1.076 E+07
	F_{MSY}		0.526	0.527
	B_{2004}/B_{MSY}		0.765	0.721
	F_{2004}/F_{MSY}		0.955	0.966

Table 3.3.1.2.1. Greater amberjack yield (whole weight in lbs) used as input for SSASPM for the period 1963-2004. Refer to text for details on the estimation of the historic data (1963-1980).

	CB+PB		HB		HL		LL	
	Index	Yield	Index	Yield	Index	Yield	Index	Yield
1963		14,318		1,700		7,081		100
1964		17,684		2,100		6,176		100
1965		21,832		2,592		5,053		100
1966		26,939		3,199		6,738		100
1967		3,326		3,945		29,197		100
1968		40,963		4,864		11,510		100
1969		50,480		5,994		72,898		100
1970		62,184		7,384		13,663		100
1971		77,637		9,219		38,461		100
1972		96,827		11,497		41,643		100
1973		120,640		14,325		28,261		100
1974		150,167		17,831		41,736		100
1975		186,754		22,175		78,139		100
1976		232,062		27,555		86,467		100
1977		288,134		34,213		119,870		100
1978		357,487		42,447		150,672		100
1979		443,219		52,627		148,748		2,714
1980		549,141		65,204		173,632		4,754
1981		1,043,546		123,909		212,666		22,450
1982		5,924,108		703,418		184,403		39,106
1983		2,835,244		336,652		233,233		45,571
1984		1,446,678		171,776		465,166		60,616
1985		1,845,062		219,079		645,207		108,229
1986	1.925	4,779,781	2.641	678,660		903,545		196,562
1987	1.952	4,489,630	1.179	359,138		1,288,095		249,456
1988	1.243	1,348,090	1.256	210,334		1,709,427		321,553
1989	2.911	5,679,784	1.705	244,852		1,636,113		295,908
1990	0.459	940,377	0.718	173,795		1,085,450		124,595
1991	1.716	3,427,895	0.564	121,409		1,369,133		6,047
1992	1.472	2,320,599	0.654	330,957		940,832		50,324
1993	0.885	2,847,441	0.462	243,942	1.071	1,489,607	0.751	80,003
1994	0.696	2,043,843	0.449	212,288	0.968	1,201,265	0.731	68,688
1995	0.473	712,905	0.718	142,929	1.191	1,177,210	0.927	81,850
1996	0.446	1,344,207	0.513	151,552	0.984	1,210,030	0.626	56,802
1997	0.304	945,735	0.500	123,054	0.764	1,055,346	0.793	59,410
1998	0.277	646,933	0.564	89,219	0.743	643,827	0.725	54,854
1999	0.371	800,407	0.551	76,351	0.877	714,753	0.700	60,437
2000	0.547	955,546	0.705	96,371	0.889	851,303	0.845	70,492
2001	0.588	1,235,599	1.179	90,583	0.956	685,581	0.907	47,253
2002	1.182	1,887,625	1.513	200,801	0.909	712,632	1.453	77,771
2003	1.033	2,494,241	1.397	194,954	1.367	873,636	1.604	125,515
2004	0.520	2,031,254	1.731	108,785	1.280	872,346	1.939	82,442

Table 3.3.1.3.1. Biological inputs for the SSASPM base model. The value of t_0 was adjusted for a birthday of June 1st.

Parameter	Value	Prior
Maturity	Age 1-2: 0.0 Age 3: 0.5 Age 4+: 1.0	(constant)
Steepness	0.7 (α = 9.33)	LN (mean=0.7 CV=0.35)
R_0	1.00E+04	Uniform [1.0E+03 – 1.0E+06]
M	0.25	(constant)
L_∞	138.9 cm (FL)	(constant)
K	0.25	(constant)
t_0	-0.3773	(constant)
L-W scalar	7.5438E-05	(constant)
L-W exponent	2.81	(constant)
Batch fecundity (at age) slope	458.601	(constant)
Batch fecundity (at age) intercept	254.065	(constant)

Table 3.3.2.2.1. SSASPM estimated parameters and benchmarks for base model (M=0.25 h=0.7).

Type	F	Y/R	SSB/SSB_0	SPR	Recruits	F/F_{MSY}	SSB/SSB_{MSY}
Virgin	0.000	0.00	1.000	1.000	3.70E+05	0.00	2.79
MSY	0.224	9.17	0.358	0.452	2.93E+05	1.00	1.00
Current (2004)	0.214	9.38	0.392	0.475	3.05E+05	0.96	1.09
MAX YPR	0.550	10.40	0.079	0.213	1.38E+05	2.46	0.22
$F_{0.1}$	0.241	9.36	0.334	0.431	2.87E+05	1.08	0.93
20% SPR	0.583	10.40	0.064	0.200	1.18 E+05	2.60	0.18
30% SPR	0.387	10.20	0.181	0.300	2.23 E+05	1.73	0.51
40% SPR	0.268	9.62	0.299	0.400	2.76 E+05	1.20	0.83
50% SPR	0.188	8.66	0.416	0.500	3.07 E+05	0.84	1.16
60% SPR	0.130	7.39	0.533	0.600	3.28 E+05	0.58	1.49

Table 3.3.2.8.1. SSASPM estimated parameters for base model (bold font) and sensitivities.

	F_{MSY}	Y_{MSY}	SSB_{MSY}	SPR_{MSY}	$Recruits_{MSY}$	F_{2004}/F_{MSY}	SSB_{2004}/SSB_{MSY}
M=0.25 h=0.7	**0.224**	**2.69E+06**	**7.65E+10**	**0.452**	**2.93E+05**	**0.96**	**1.09**
M=0.20-h=0.7	0.200	2.61E+06	7.93E+10	0.428	2.29E+05	0.99	1.08
M=0.35-h=0.7	0.259	2.78E+06	7.28E+10	0.495	4.49E+05	0.90	1.13
M=0.25-h=0.8	0.267	2.90E+06	6.95E+10	0.399	3.02E+05	0.68	1.40
M=0.25-h=0.9	0.379	3.63E+06	6.07E+10	0.295	3.56E+05	0.33	2.24

Table 6.2.1. Projected biomass for different values of $F/F_{current}$ for the greater amberjack stock. The column labeled '1' corresponds to projections made with the current level of F; the column labeled '0' has projections with no fishing; and the column labeled '0.9' has projections with F at 90% of the current level.

YEAR	1	0.9	0.8	0.7	0.6	0.5	0
2005	7.852E+06	7.852E+06	7.852E+06	7.852E+06	7.852E+06	7.852E+06	7.852E+06
2006	8.481E+06	8.831E+06	9.194E+06	9.568E+06	9.956E+06	1.036E+07	1.257E+07
2007	8.926E+06	9.534E+06	1.017E+07	1.084E+07	1.153E+07	1.226E+07	1.628E+07
2008	9.226E+06	1.001E+07	1.082E+07	1.167E+07	1.255E+07	1.345E+07	1.834E+07
2009	9.423E+06	1.031E+07	1.122E+07	1.217E+07	1.313E+07	1.412E+07	1.926E+07
2010	9.549E+06	1.049E+07	1.146E+07	1.245E+07	1.346E+07	1.447E+07	1.964E+07
2011	9.630E+06	1.061E+07	1.160E+07	1.261E+07	1.363E+07	1.465E+07	1.978E+07
2012	9.680E+06	1.067E+07	1.168E+07	1.270E+07	1.371E+07	1.474E+07	1.984E+07
2013	9.712E+06	1.072E+07	1.173E+07	1.274E+07	1.376E+07	1.478E+07	1.986E+07
2014	9.732E+06	1.074E+07	1.175E+07	1.277E+07	1.378E+07	1.480E+07	1.987E+07
2015	9.744E+06	1.075E+07	1.177E+07	1.278E+07	1.380E+07	1.481E+07	1.987E+07
2016	9.752E+06	1.076E+07	1.178E+07	1.279E+07	1.380E+07	1.481E+07	1.987E+07
2017	9.757E+06	1.077E+07	1.178E+07	1.279E+07	1.381E+07	1.482E+07	1.987E+07
2018	9.760E+06	1.077E+07	1.178E+07	1.279E+07	1.381E+07	1.482E+07	1.987E+07
2019	9.761E+06	1.077E+07	1.178E+07	1.280E+07	1.381E+07	1.482E+07	1.987E+07
2020	9.763E+06	1.077E+07	1.179E+07	1.280E+07	1.381E+07	1.482E+07	1.987E+07

Table 6.2.2. Projected yield for different values of $F/F_{current}$ for the greater amberjack stock. The column labeled '1' corresponds to projections made with the current level of F; the column labeled '0' has projections with no fishing; and the column labeled '0.9' has projections with F at 90% of the current level.

YEAR	1	0.9	0.8	0.7	0.6	0.5	0
2005	4.034E+06	3.711E+06	3.372E+06	3.017E+06	2.644E+06	2.253E+06	0.000E+00
2006	4.297E+06	4.084E+06	3.830E+06	3.534E+06	3.193E+06	2.802E+06	0.000E+00
2007	4.479E+06	4.342E+06	4.149E+06	3.894E+06	3.573E+06	3.181E+06	0.000E+00
2008	4.600E+06	4.511E+06	4.353E+06	4.120E+06	3.806E+06	3.407E+06	0.000E+00
2009	4.678E+06	4.617E+06	4.477E+06	4.252E+06	3.937E+06	3.529E+06	0.000E+00
2010	4.729E+06	4.683E+06	4.550E+06	4.326E+06	4.008E+06	3.591E+06	0.000E+00
2011	4.760E+06	4.722E+06	4.592E+06	4.368E+06	4.045E+06	3.623E+06	0.000E+00
2012	4.780E+06	4.746E+06	4.617E+06	4.390E+06	4.064E+06	3.638E+06	0.000E+00
2013	4.793E+06	4.760E+06	4.630E+06	4.402E+06	4.074E+06	3.645E+06	0.000E+00
2014	4.801E+06	4.768E+06	4.638E+06	4.408E+06	4.079E+06	3.649E+06	0.000E+00
2015	4.805E+06	4.773E+06	4.642E+06	4.412E+06	4.081E+06	3.651E+06	0.000E+00
2016	4.808E+06	4.776E+06	4.645E+06	4.414E+06	4.083E+06	3.652E+06	0.000E+00
2017	4.810E+06	4.778E+06	4.646E+06	4.415E+06	4.083E+06	3.652E+06	0.000E+00
2018	4.811E+06	4.779E+06	4.647E+06	4.415E+06	4.084E+06	3.652E+06	0.000E+00
2019	4.812E+06	4.780E+06	4.647E+06	4.416E+06	4.084E+06	3.652E+06	0.000E+00

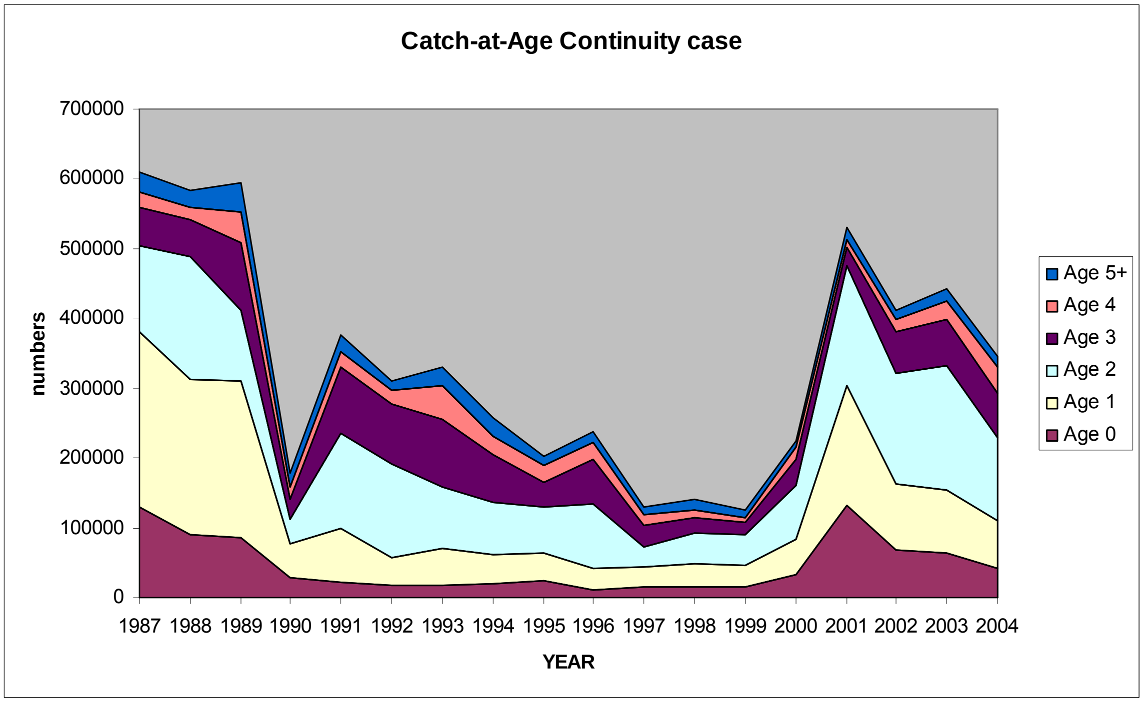


Figure 3.1.1.2.1. Catch-at-age distribution applied in the Continuity Case-VPA model.

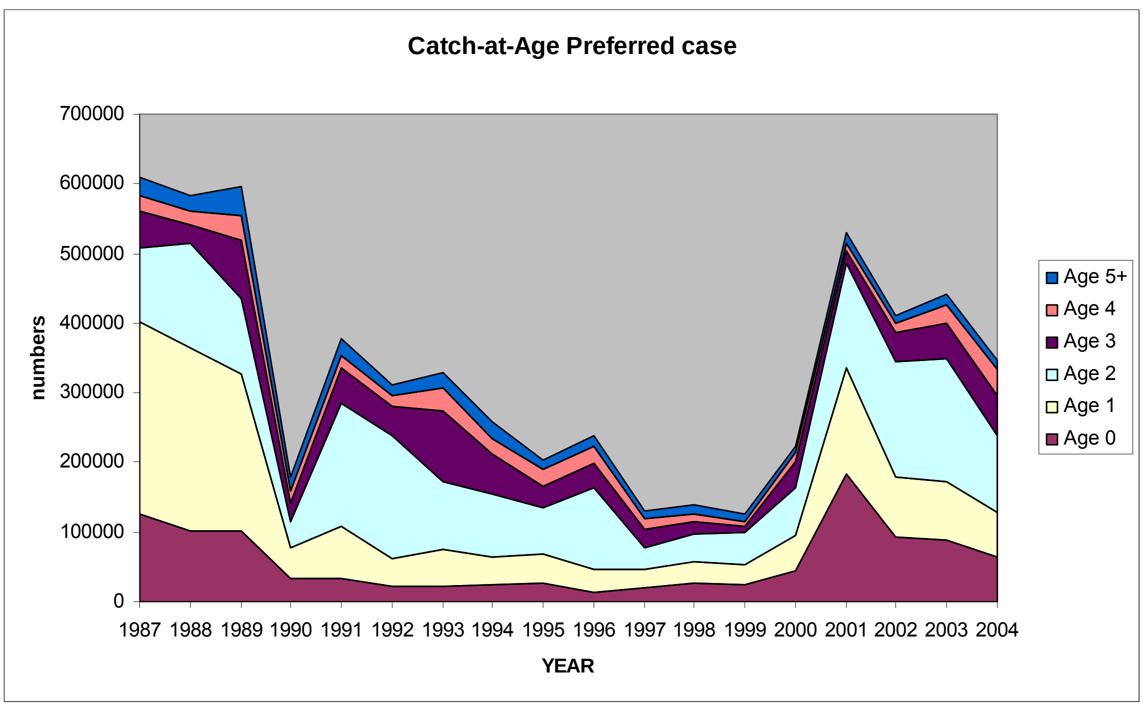


Figure 3.1.1.2.2. Catch-at-age distribution applied in the Preferred Case-VPA model.

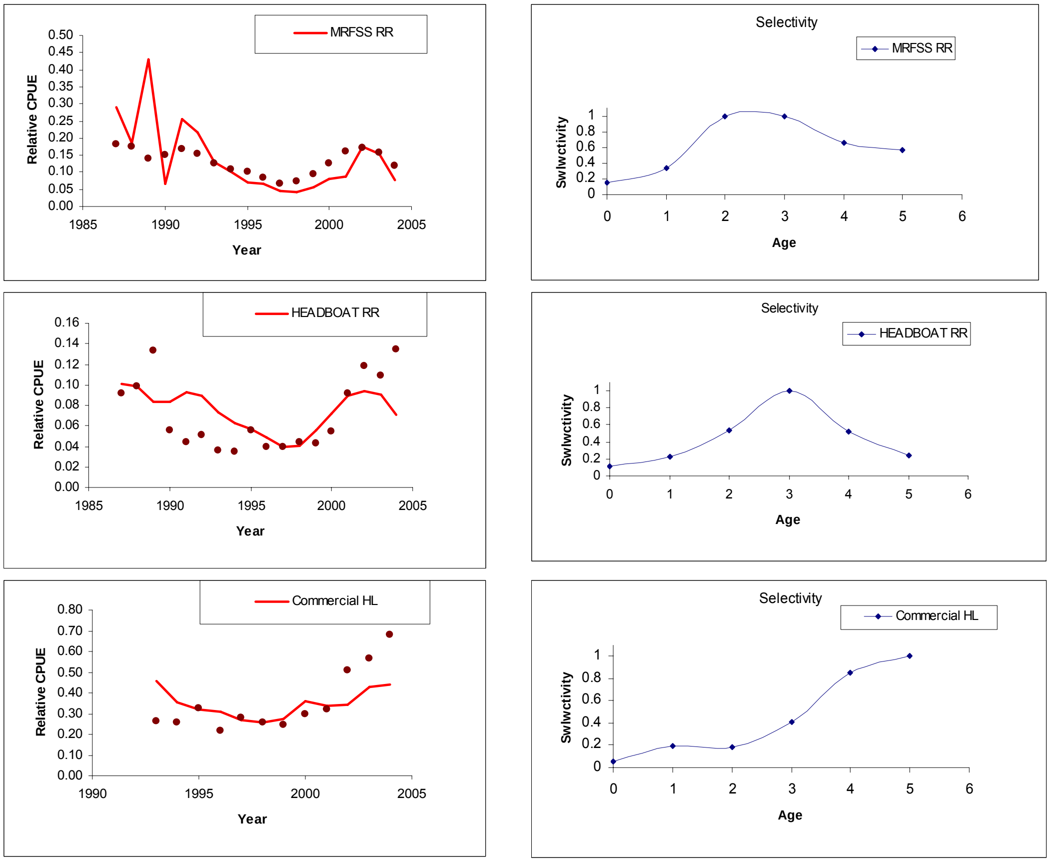


Figure 3.1.2.1.1. Fits of abundance indices (left) and selectivity patterns (right) for the Continuity Case-VPA.

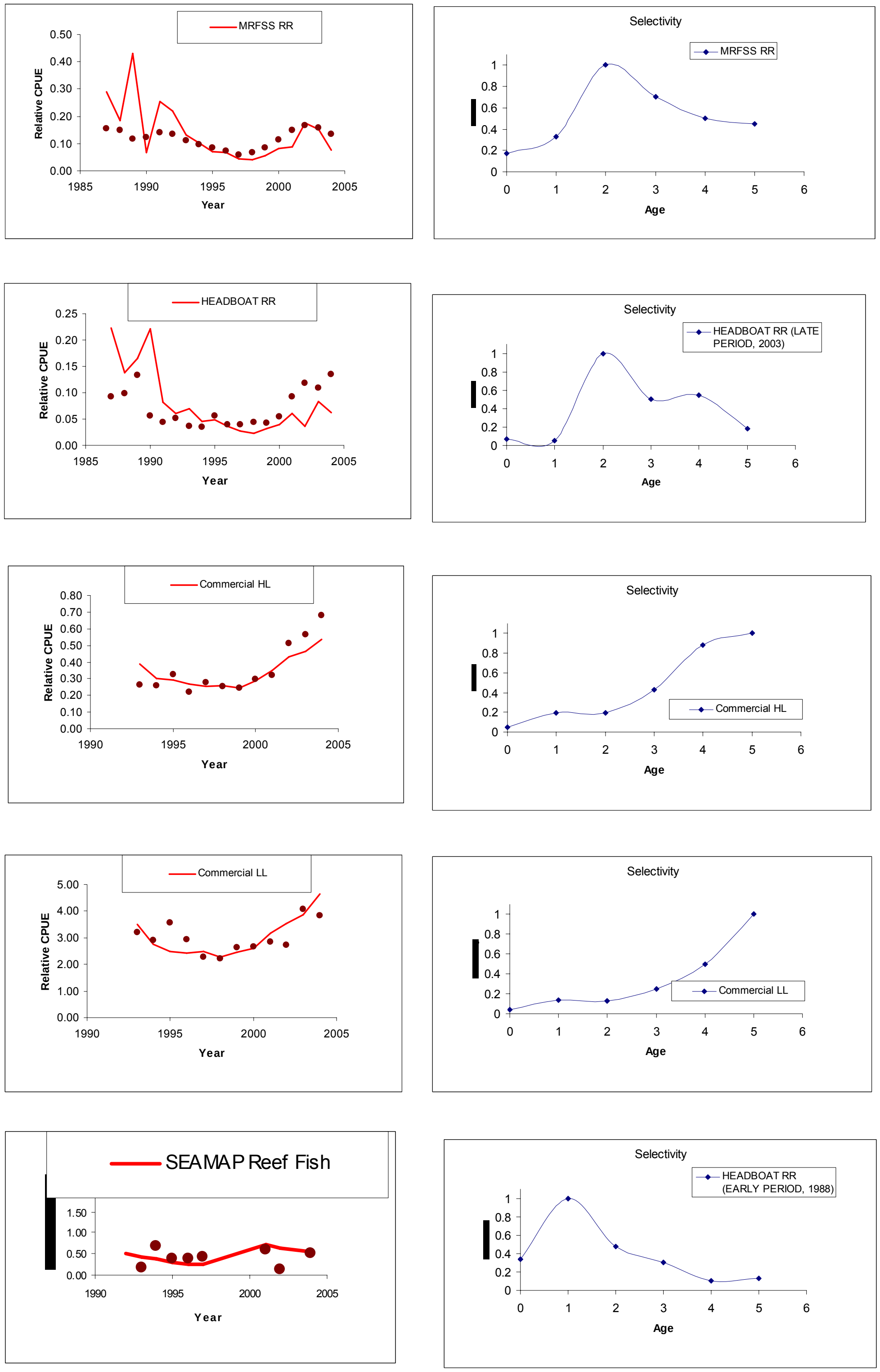


Figure 3.1.2.1.2. Fits of abundance indices (left) and the selectivity patterns (right) for the Preferred Case-VPA (Option 4). NOTE: The graph in the lower right is not the selectivity pattern for the SEAMAP index (which was assumed to be evenly selected across ages), but rather it is the headboat selectivity pattern in 1988.

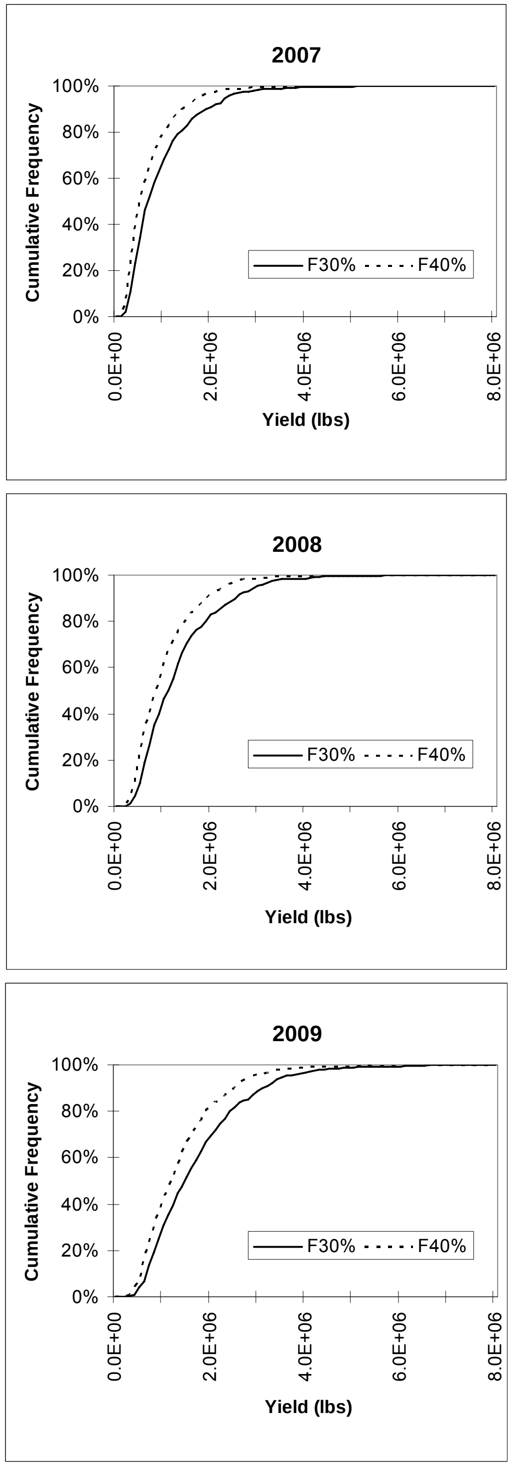


Figure 3.1.2.2.1. Cumulative frequency distribution of predicted future yields from the Continuity Case-VPA results under F30% and F40% for 2007, 2008 and 2009.

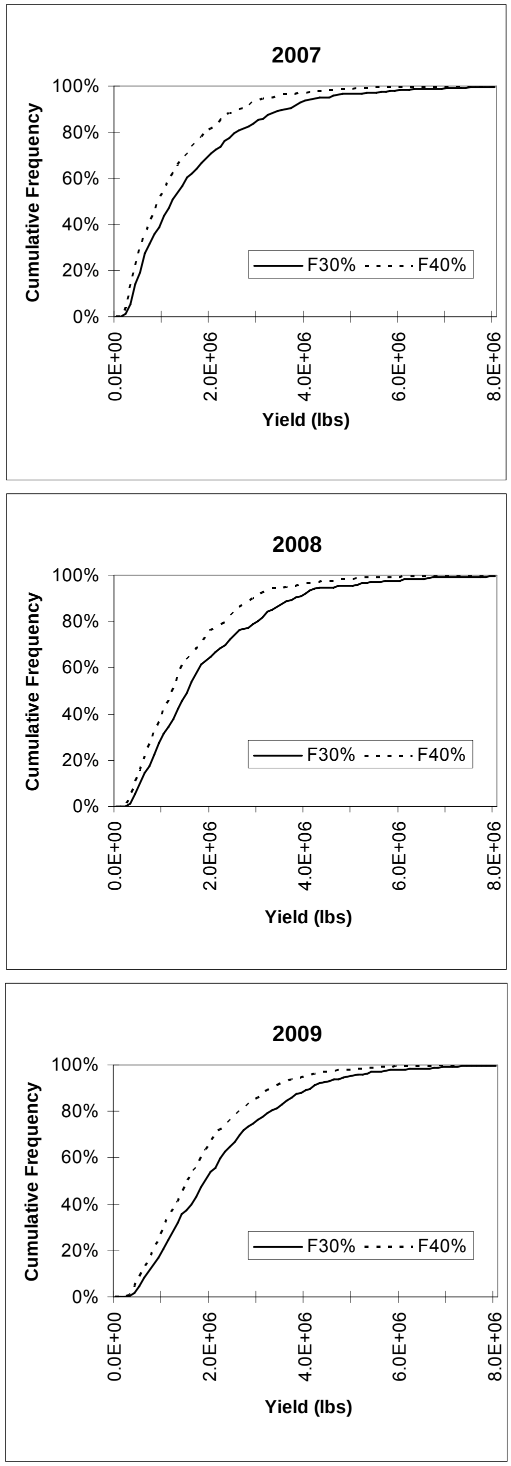


Figure 3.1.2.2.2. Cumulative frequency distribution of predicted future yields from the Preferred Case-VPA (Option 4) results under F30% and F40% for 2007, 2008 and 2009.

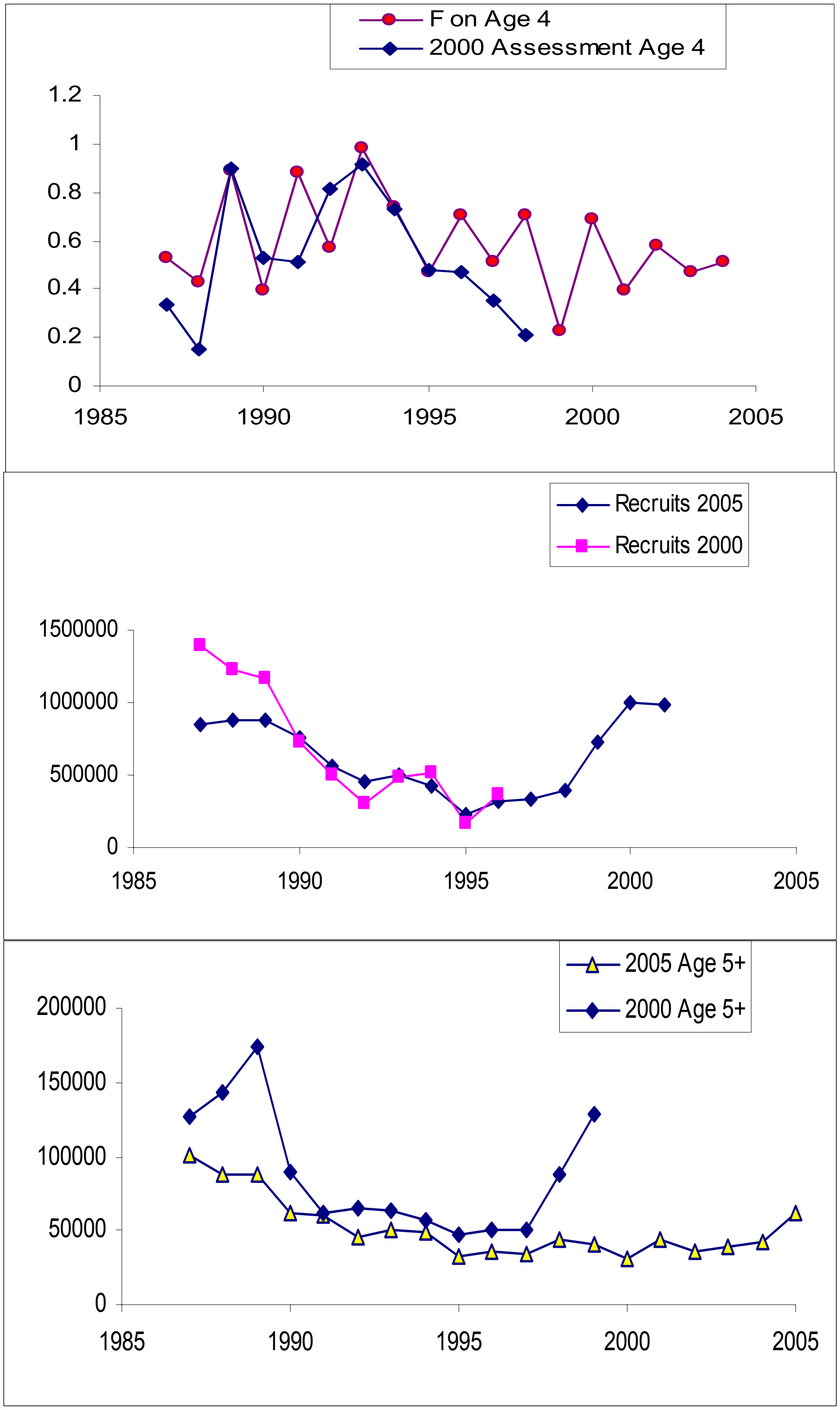
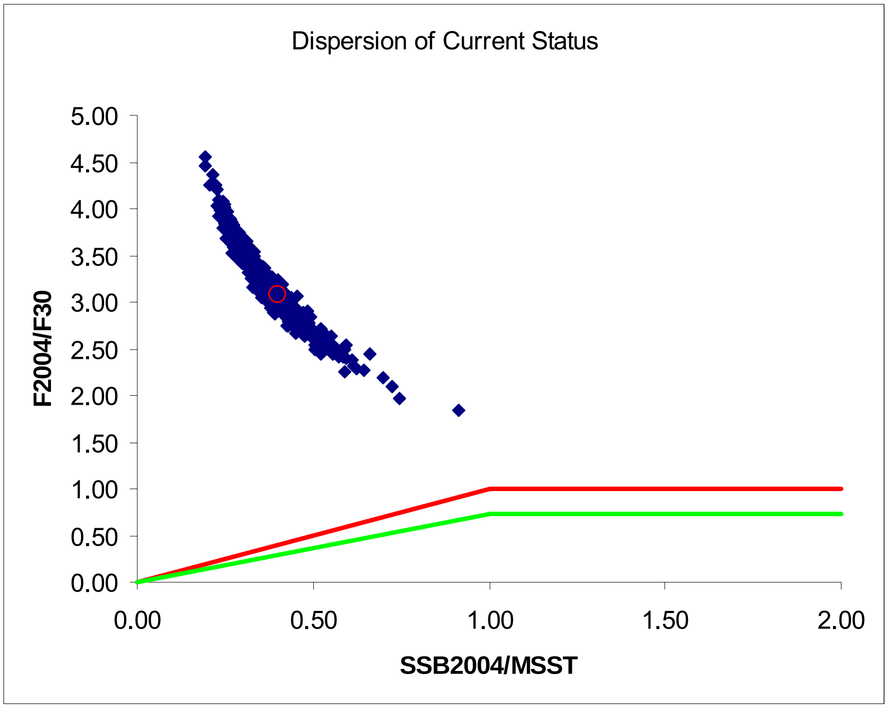


Figure 3.1.2.2.3. Comparison of selected results from Continuity Case-VPA to VPA results from the 2000 assessment.



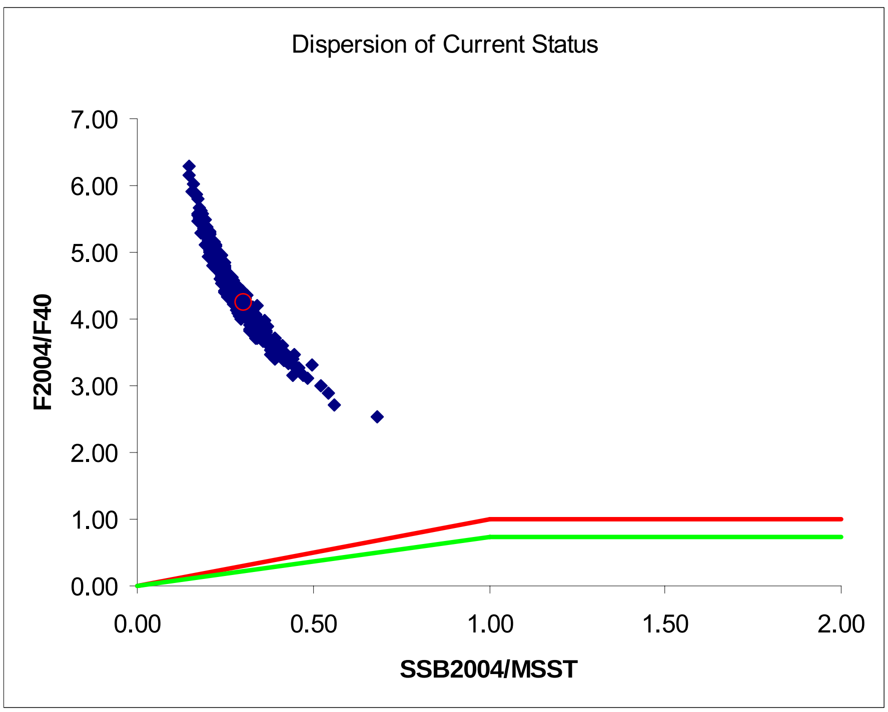
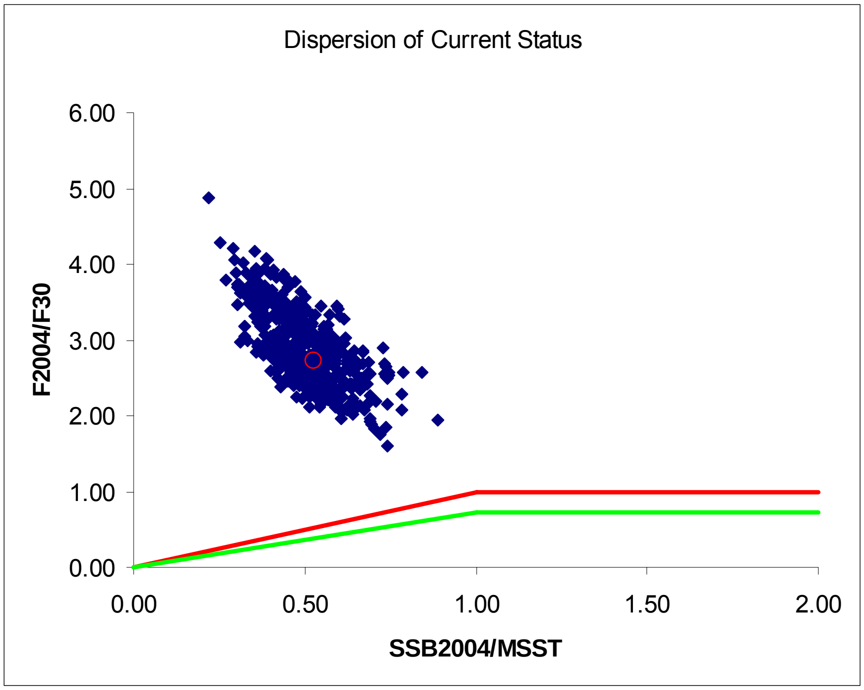


Figure 3.1.2.4.1. Estimates of stock status in the terminal year based on 501 bootstrap results for the Continuity Case-VPA. Open red circle represents the deterministic outcome. The solid red line represents an MFMT control rule and the solid green line represents an OY target control rule.



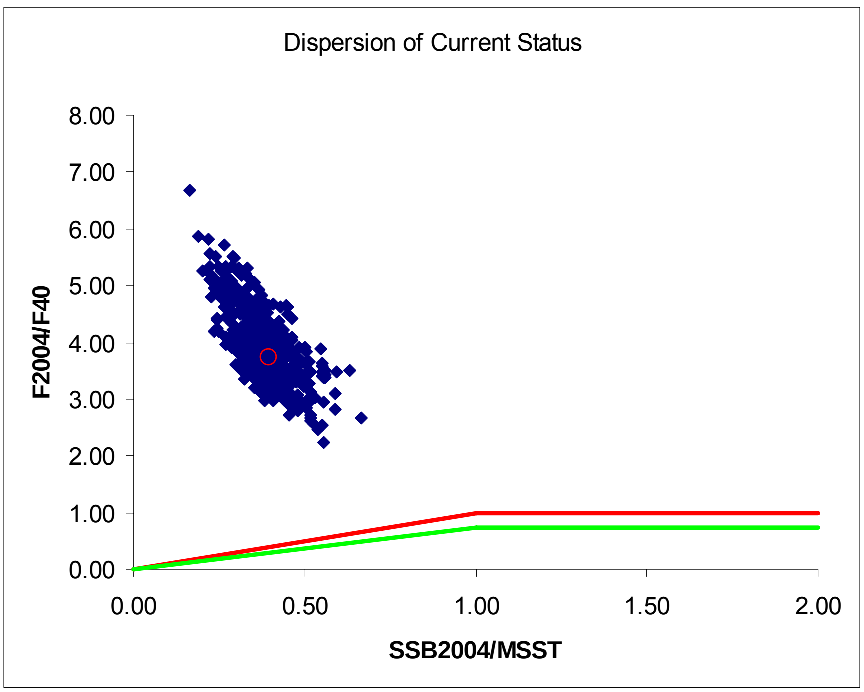


Figure 3.1.2.4.2. Estimates of stock status in the terminal year based on 501 bootstrap results for the Preferred Case-VPA (Option 4). Open red circle represents the deterministic outcome. The solid red line represents an MFMT control rule and the solid green line represents an OY target control rule.

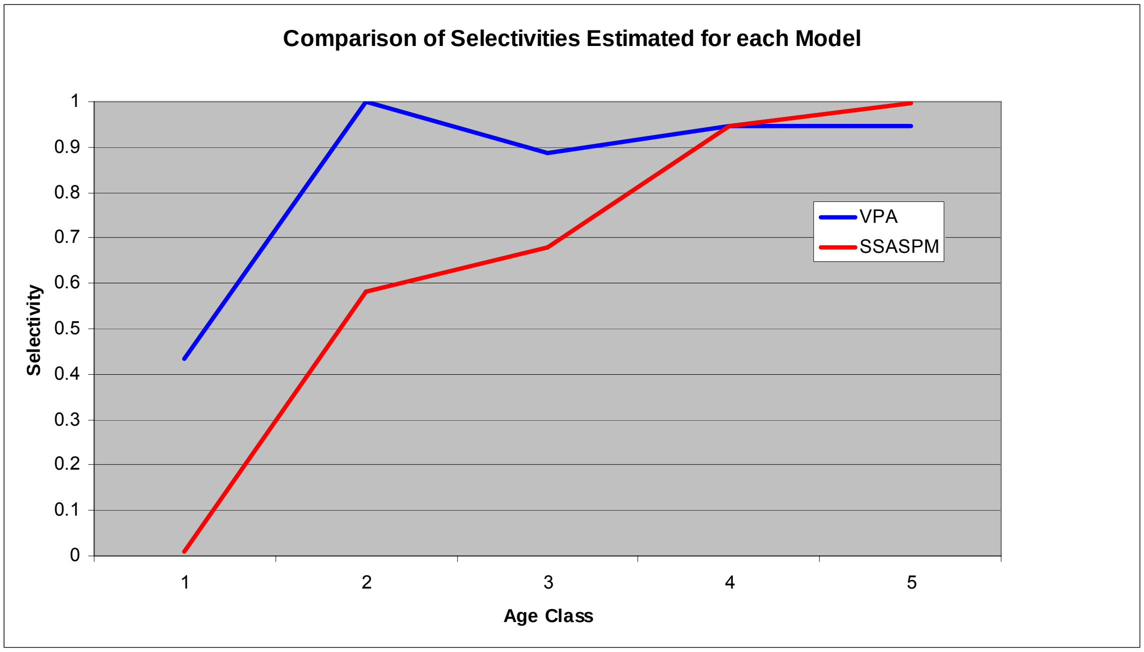


Figure 3.1.2.5.1. Comparison of the selectivity patterns estimated by VPA and SSASPM.

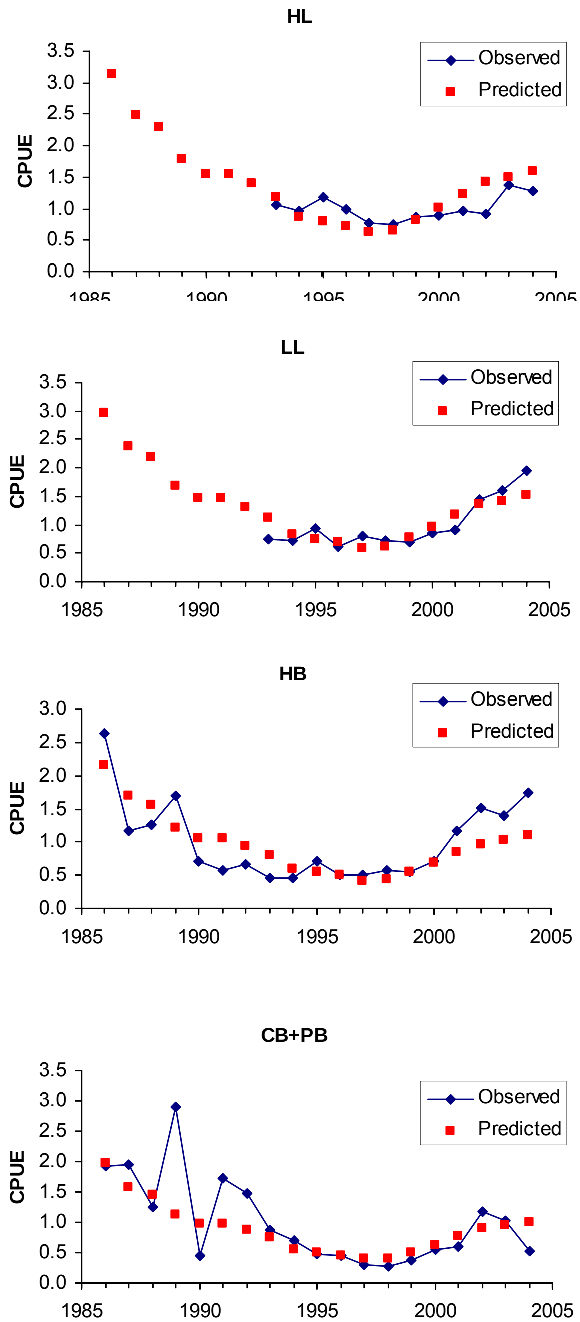


Figure 3.2.2.1.1. ASPIC estimated and observed CPUE series for the commercial handline (HL), longline (LL), recreational headboat (HB) and charterboat-private boat (CB+PB) fisheries.

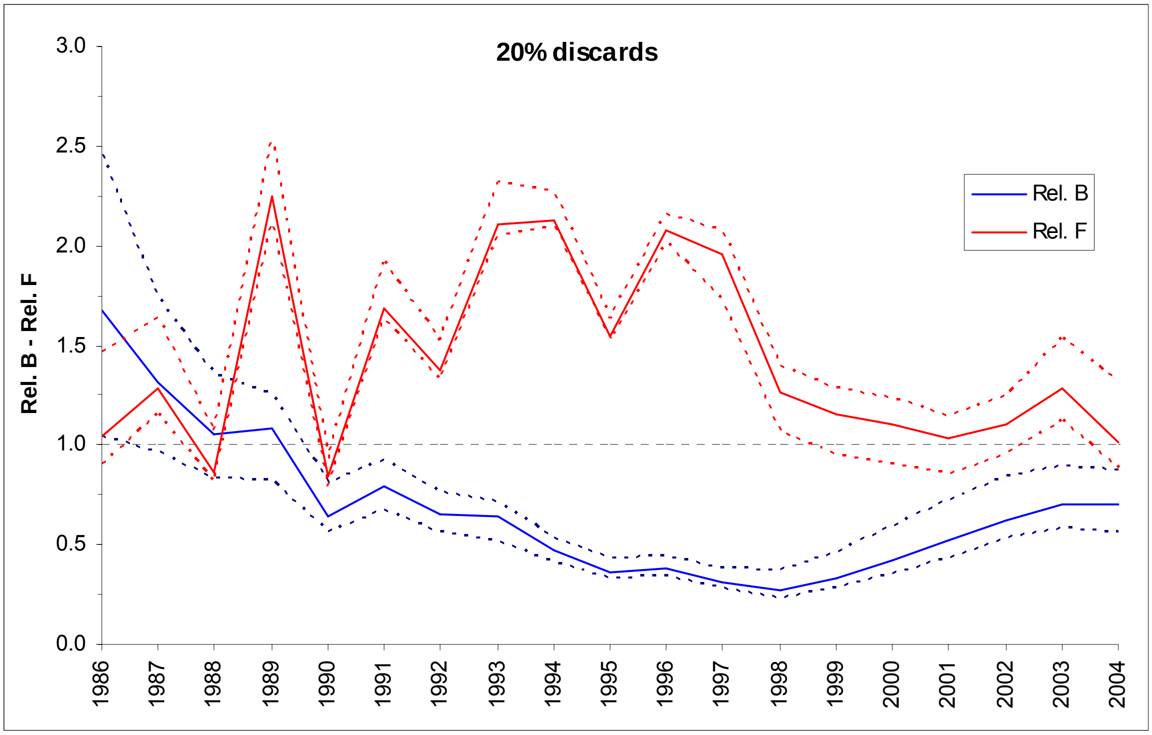


Figure 3.2.2.3.1. ASPIC estimated relative biomass (B/B_{MSY}) and relative F (F/F_{MSY}) trajectories assuming 20% discard mortality. Dashed lines correspond to 10-90th percentiles

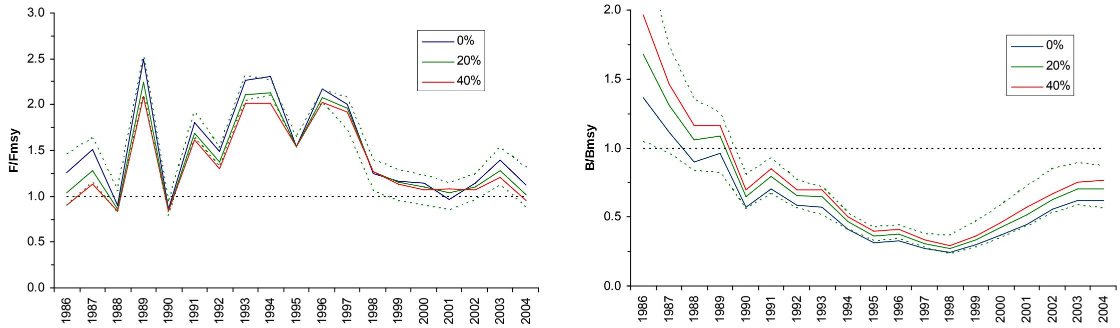


Figure 3.2.2.6.1. ASPIC estimated relative F (F/F_{MSY}) and relative biomass (B/B_{MSY}) for three levels of discard mortality. Dashed lines correspond to estimated 10-90th percentiles for the base case (20% discard mortality).

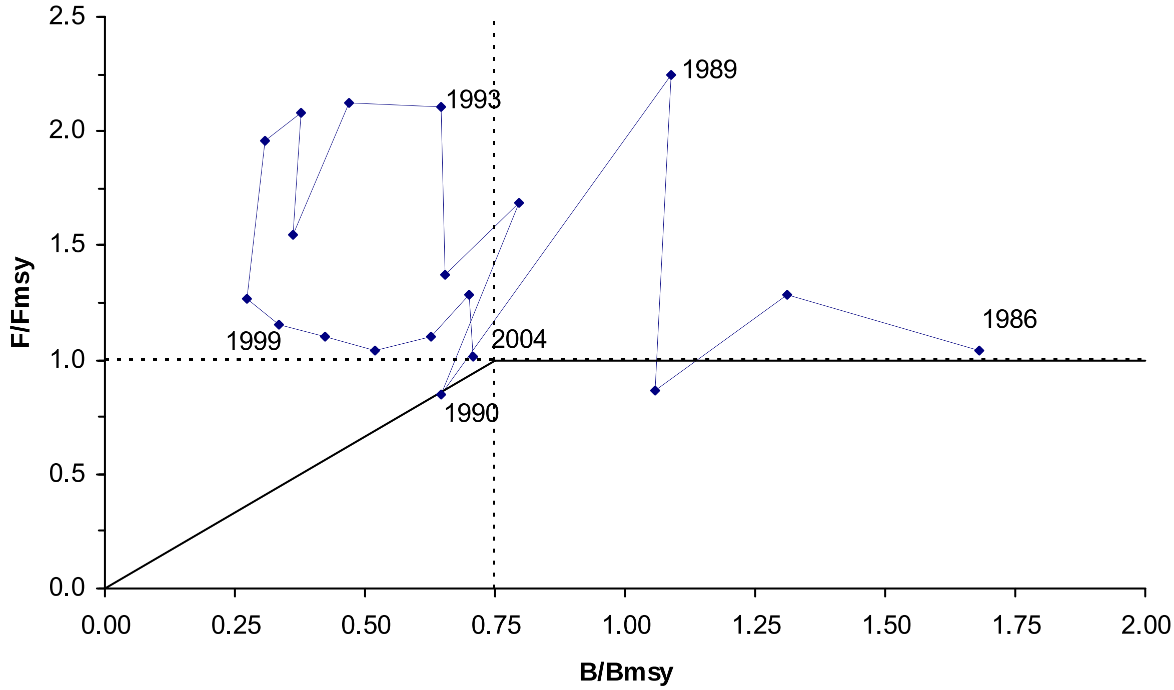


Figure 3.2.2.3.2. Status of greater amberjack with respect to F/Fmsy and B/Bmsy for ASPIC. The limit and threshold control rules are shown by dashed lines.

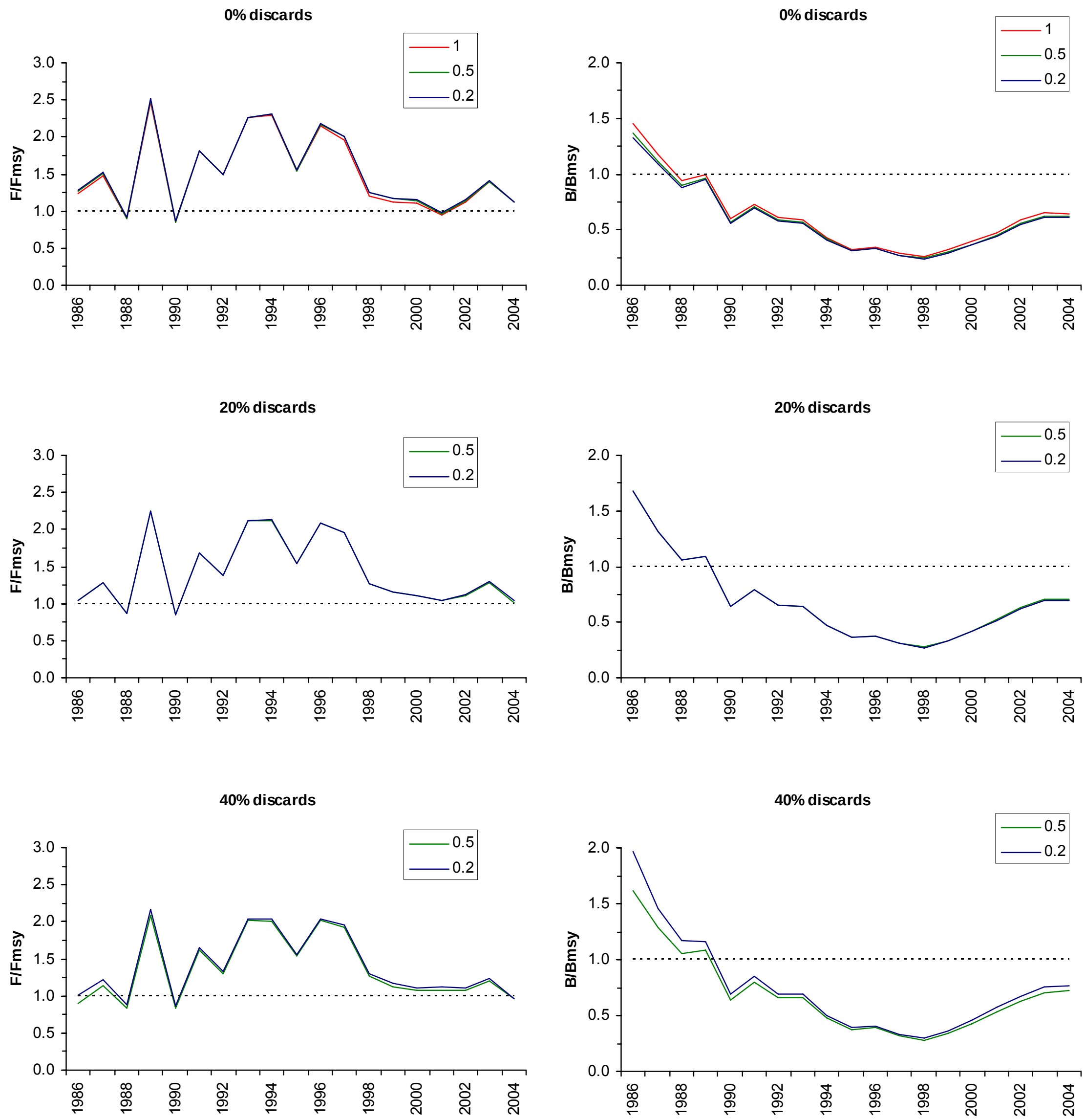


Figure 3.2.2.6.2. ASPIC estimated relative F (F/F_{MSY}) and relative biomass (B/B_{MSY}) for three levels of discard mortality and initial values of B_1/K.

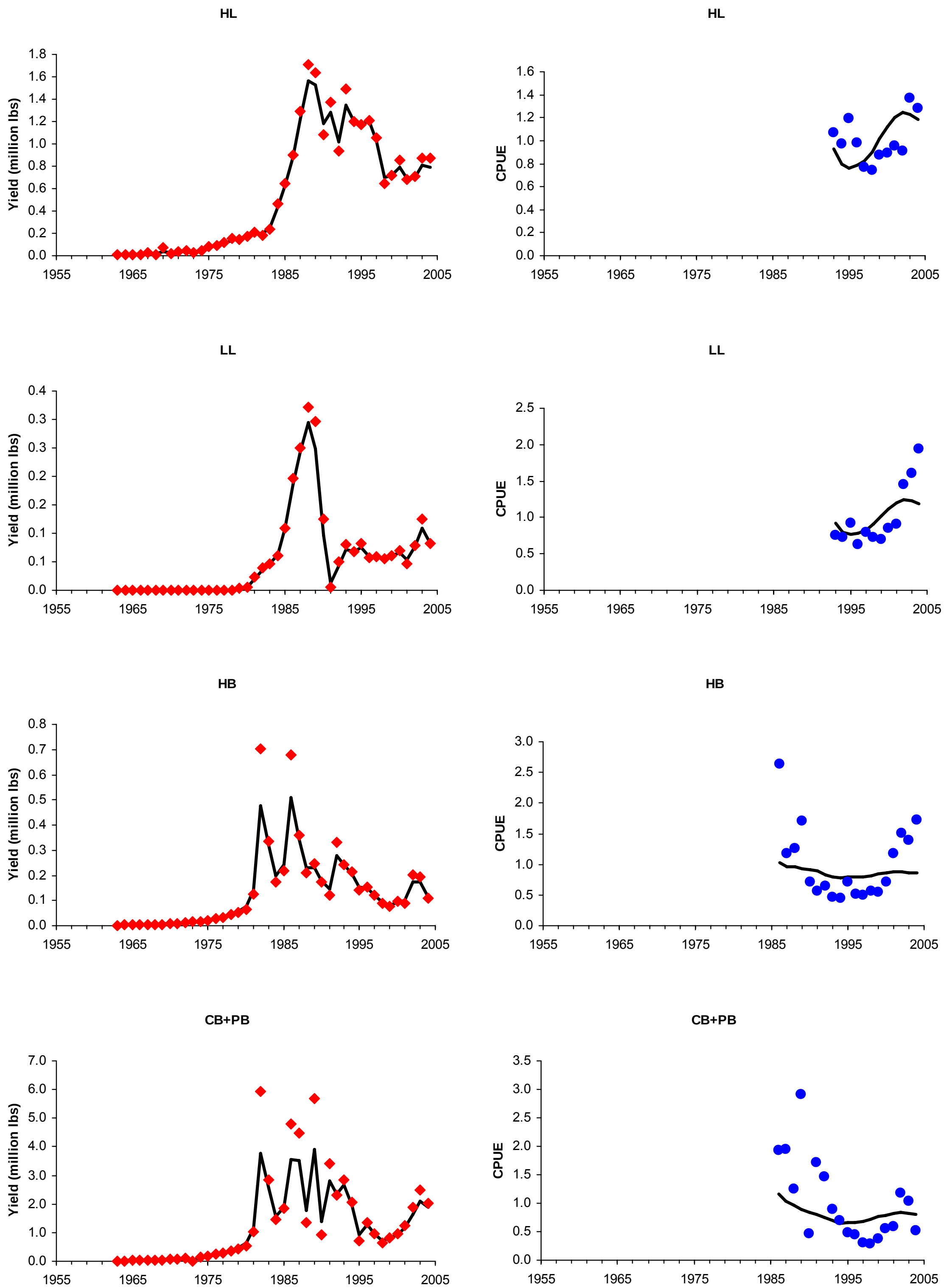


Figure 3.3.2.1.1. SSASPM fits to yield (left panels) and indices of abundance (right panels).

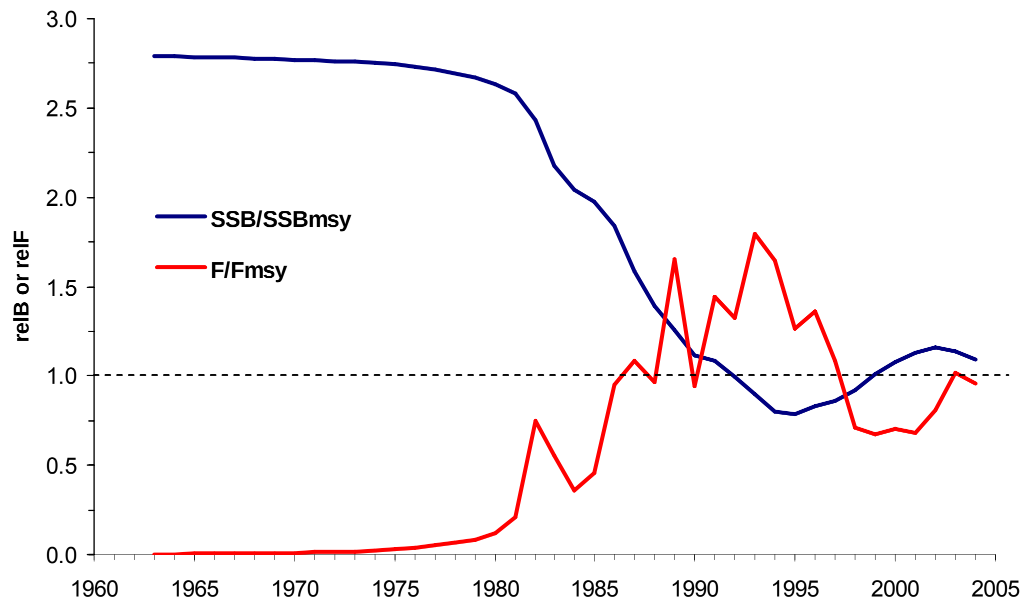


Figure 3.3.2.4.1. SSASPM estimated relative F (F/F_{MSY}) and relative SSB (SSB/SSB_{MSY}).

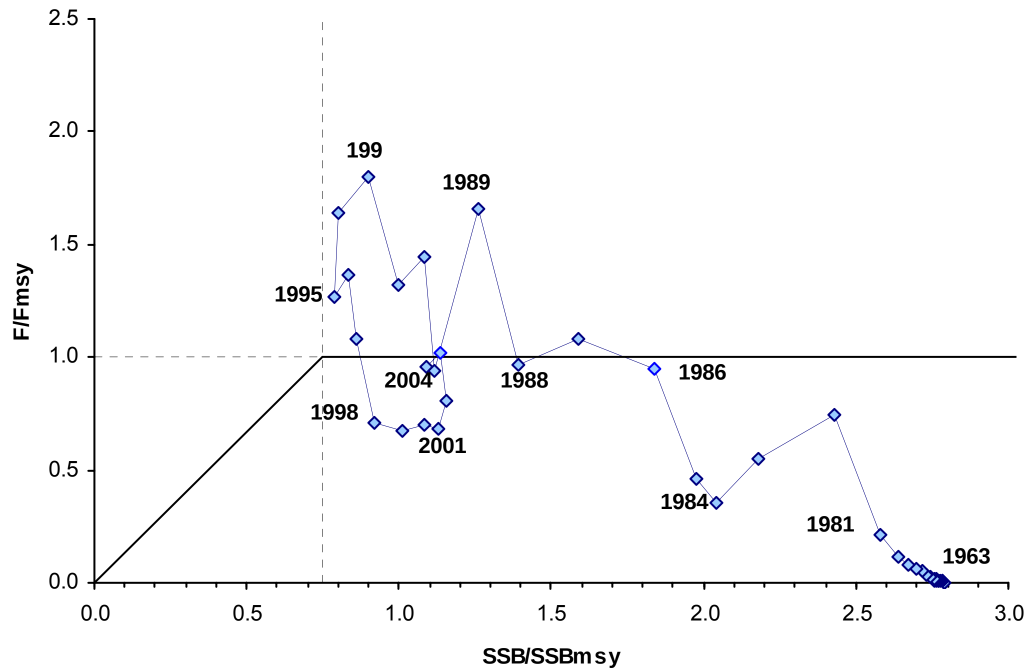


Figure 3.3.2.4.2. Status of greater amberjack with respect to F/Fmsy and SSB/SSBmsy based on SSASPM. The limit and threshold control rules are shown by dashed lines.

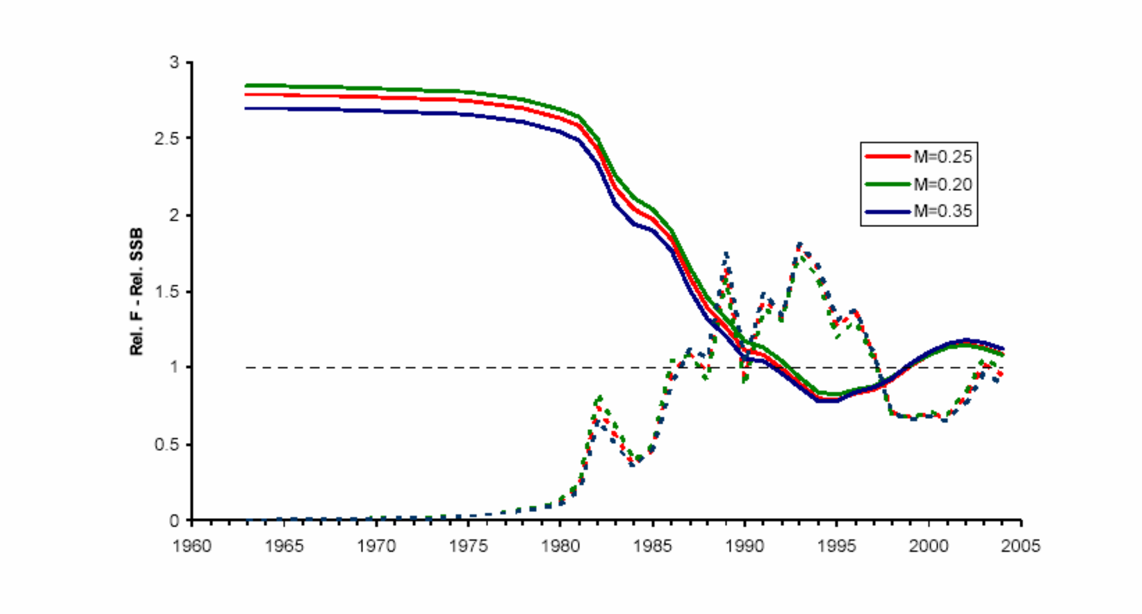


Figure 3.3.2.8.1. SSASPM estimated relative SSB (SSB/SSB_{MSY}) (solid lines) and relative F (F/F_{MSY}) (dashed lines) for base case (M=0.25) and two other levels of natural mortality (M=0.2, M=0.35).

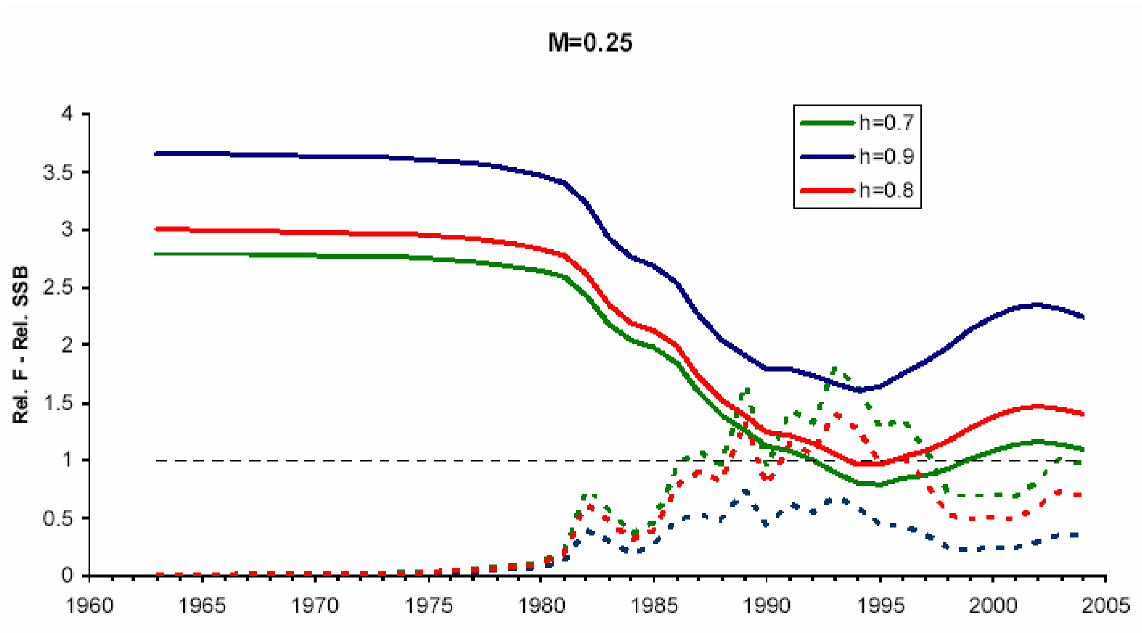


Figure 3.3.2.8.2. SSASPM estimated relative SSB (SSB/SSB_{MSY}) (solid lines) and relative F (F/F_{MSY}) (dashed lines) for three levels for the steepness prior (M=0.25).

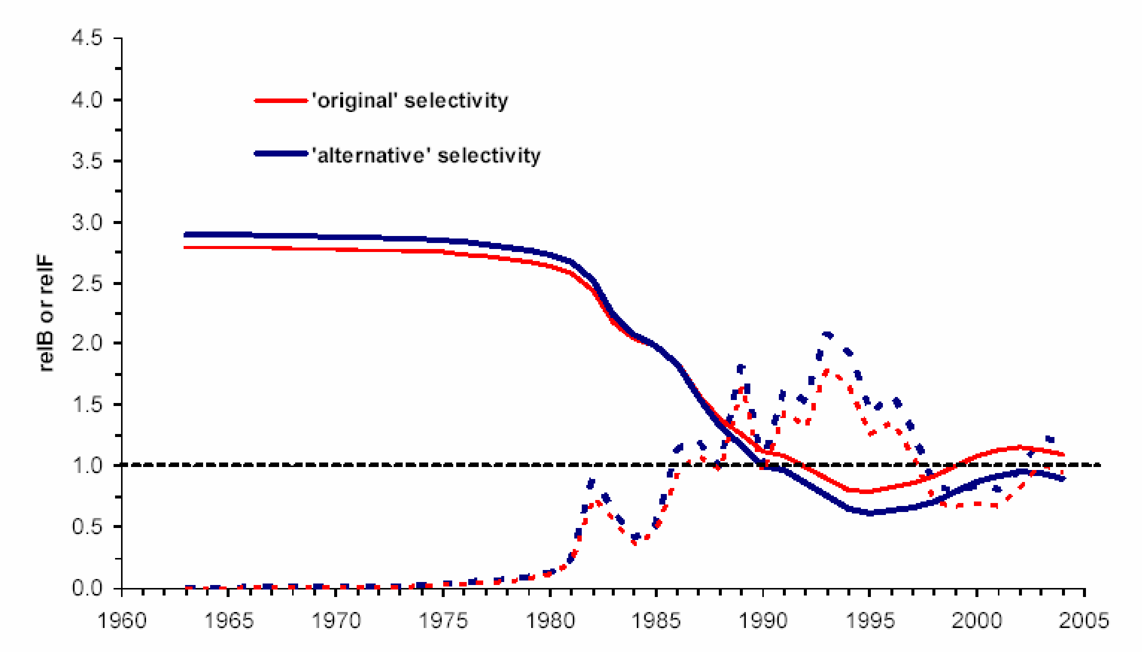


Figure 3.3.2.8.3. SSASPM estimated relative SSB (SSB/SSB_{MSY}) (solid lines) and relative F (F/F_{MSY}) (dashed lines) for two different gear selectivities.

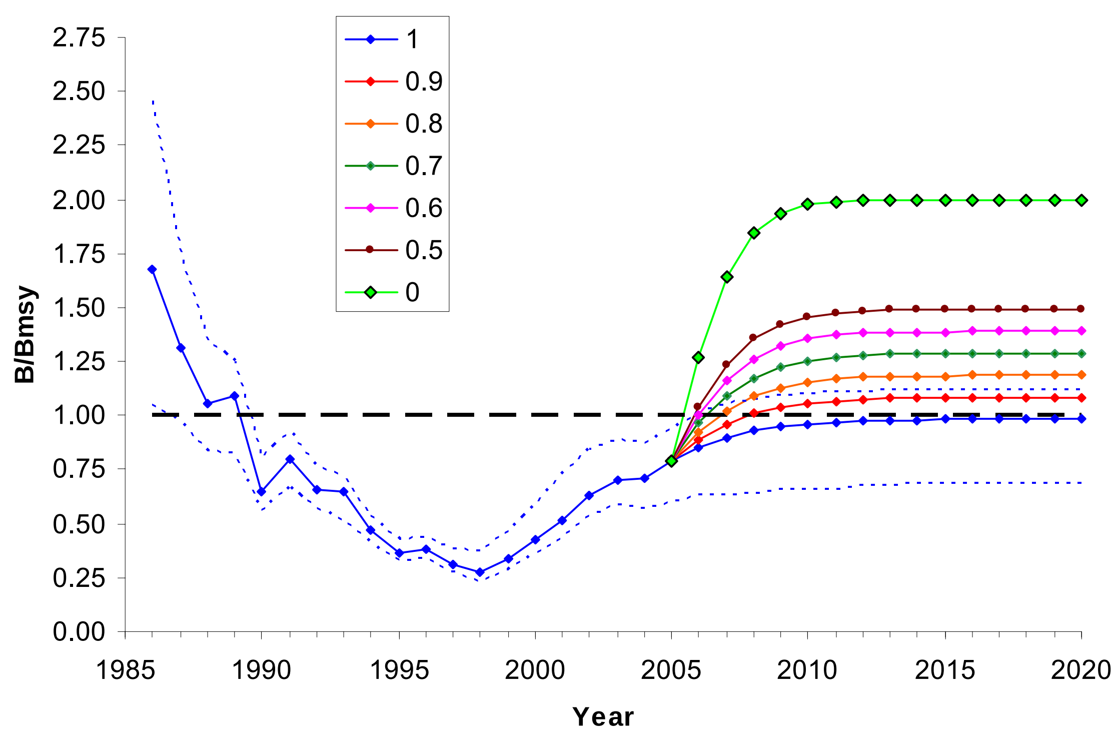


Figure 6.2.1. ASPIC estimated relative biomass (B/B_{msy}) and projected values for different constant values of F/F_{2004}.

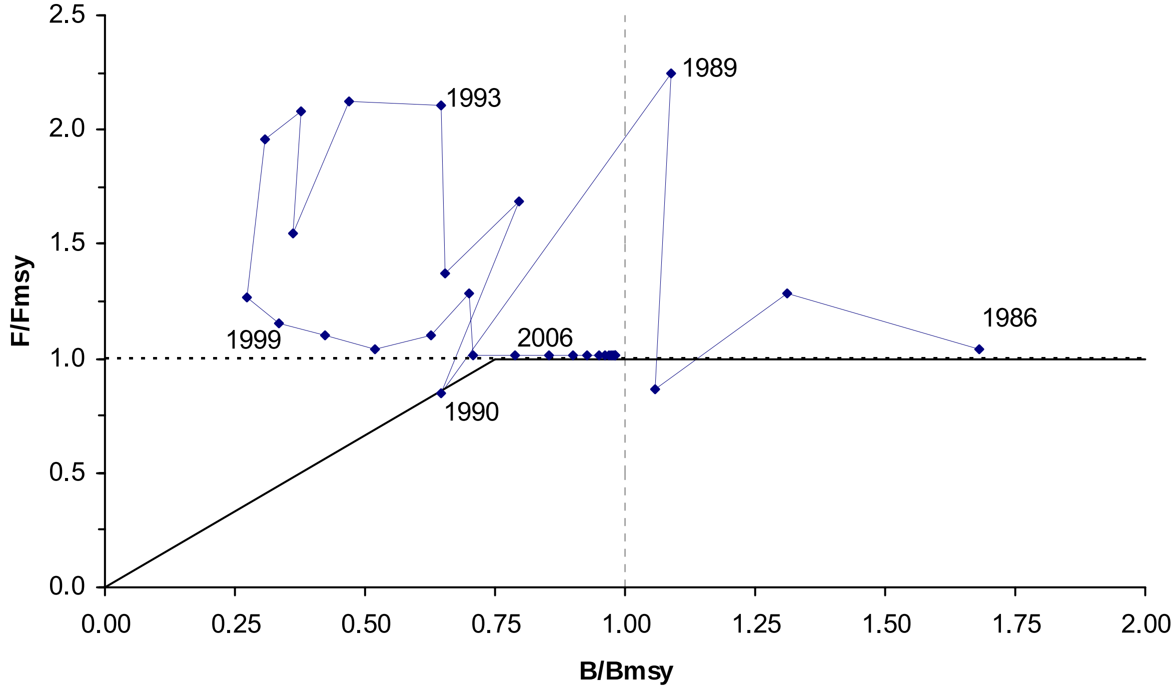


Figure 6.2.2. Projected status of greater amberjack based on ASPIC with respect to F/FMSY and B/B_{MSY}. The limit and threshold control rules for a rebuilding stock are shown by dashed lines.

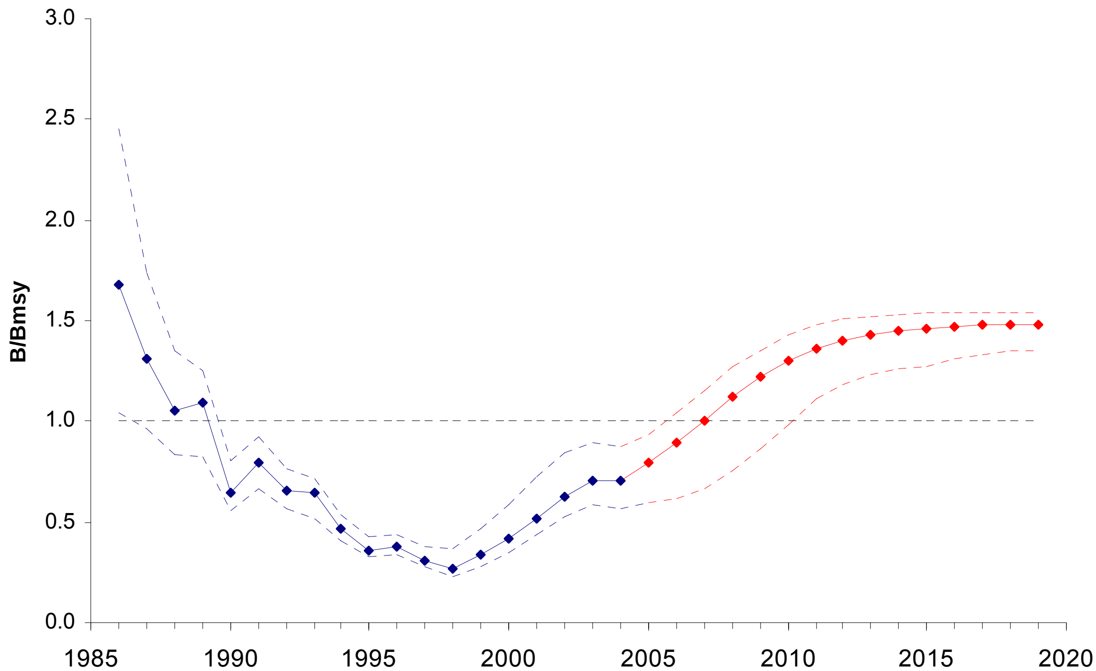


Figure 6.2.3. ASPIC estimated projected relative biomass (B/B_{MSY}) for constant values of catch for 2005-2019. Dashed lines correspond to 10-90th percentiles of bootstrap.

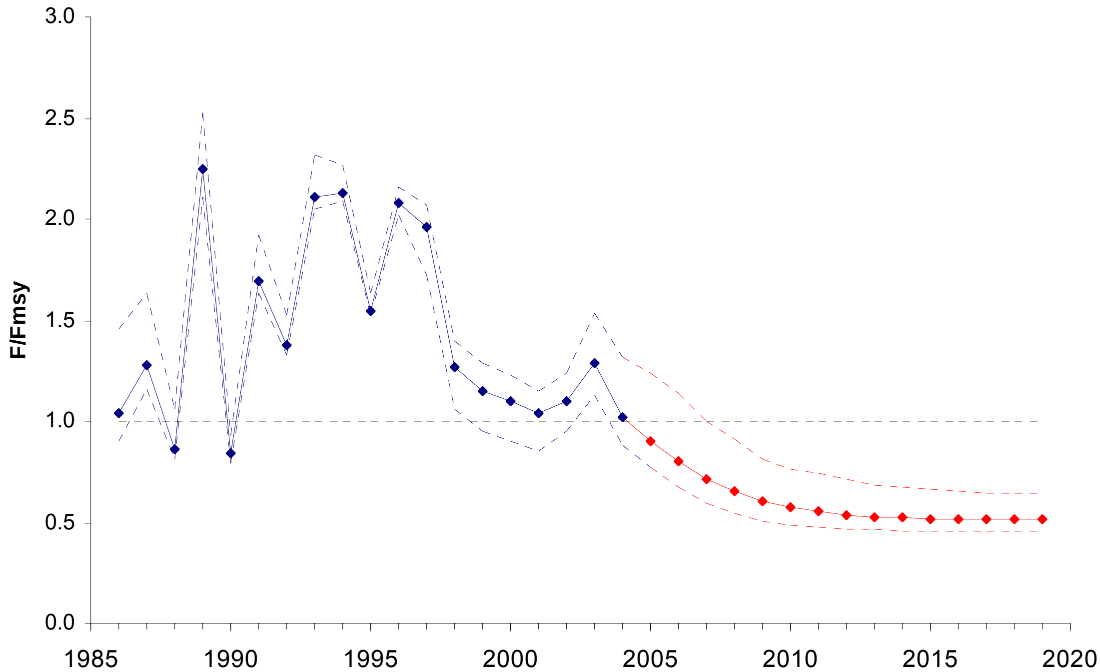


Figure 6.2.4. ASPIC estimated projected relative F (F/F_{MSY}) for constant values of catch for 2005-2019. Dashed lines correspond to 10-90th percentiles of bootstrap.